Draft Final Report

Site 11 (Building 1011 Area) Remedial Investigation

Buckley Air Force Base

460th Space Wing
Air Force Space Command

November 2010

DRAFT FINAL
REMEDIAL INVESTIGATION REPORT FOR
SITE 11 (BUILDING 1011 AREA)

BUCKLEY AIR FORCE BASE, COLORADO

November 2010

Air Force Center for Engineering and the Environment
(AFCEE/ACV)
Lackland Air Force Base, Texas 78236-9853

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14. ABSTRACT

This Remedial Investigation (RI) Report for the Site 11 (Building 1011 Area) at Buckley Air Force Base documents the rationale, procedures, results, and assessment of the three phases of field work conducted from March 2009 through September 2010 to investigate groundwater contaminated by chlorinated solvents. Two areas of groundwater contamination were delineated: a tetrachloroethene (PCE) plume that extends off base to East Toll Gate Creek, and a smaller solvent plume area on base. Real-time groundwater sampling and analysis were used to delineate the PCE plume. Sampling of surface water and sediment in East Toll Gate Creek indicated minimal impact. The baseline human health risk assessment indicated for current use scenarios, exposure to the groundwater does not present elevated levels of risk. Under unlikely future (residential and commercial building) use scenarios, exposure to contaminants in groundwater from ingestion and inhalation of indoor air, pose potential risks in excess of EPA and Colorado target levels.

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IRP, Remedial Investigation, Site 11, Building 1011, chlorinated solvents, tetrachloroethene, PCE, Area of Concern, groundwater, surface water, creek

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ACRONYMS AND ABBREVIATIONS

ABW	Air Base Wing
ACM	asbestos-containing material
ADD	average daily dose
AF	Air Force
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AFSPC	Air Force Space Command
ANG	Air National Guard
AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
AST	above ground storage tank
ATc	carcinogenic averaging time
ATEC	ATEC Associates, Inc.
ATnc	non-carcinogenic averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BDCM	bromodichloromethane
BFI	Browning-Ferris Industries
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
BW	body weight
CAG	Carcinogen Assessment Group
CBSG	Colorado Basic Standards for Groundwater
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CDI	chronic daily intake
CDLE	Colorado Department of Labor and Employment
CDPHE	Colorado Department of Public Health and Environment
CE	Civil Engineering
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	cubic centimeters
COC	chemical of concern
COPC	chemical of potential concern
CSEV	Colorado Soil Evaluation Value
CSM	conceptual site model
CWA	Clean Water Act
DADS	Denver Arapahoe Disposal Site
DA_{event}	absorbed dose per event
DCA	dichloroethane
DCE	dichloroethene
DMA	demonstration of methods applicability
DNAPL	dense nonaqueous phase liquid
DO	dissolved oxygen
DOD	Department of Defense
DWS	dynamic work strategy

ACRONYMS AND ABBREVIATIONS

EAL	Entry Authorization Letter
EBS	Environmental Baseline Survey
ED	exposure duration
EE/CA	Engineering Evaluation/Cost Analysis
EF	exposure frequency
EM	electromagnetic
EPA	Environmental Protection Agency
EPC	exposure point concentration
ERP	Environmental Restoration Program
EV	event frequency
FEMA	Federal Emergency Management Agency
FID	flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
GC	gas chromatography
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IDW	investigation-derived waste
IR	infrared
IR-SW	ingestion rate for surface water
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
Kg	kilogram
L	liters
LADD	lifetime average daily dose
LDC	Leadership Development Center
LNAPL	light nonaqueous phase liquid
MCL	maximum contaminant level
MDL	method detection limit
MEK	methyl ethyl ketone
Metro	Metro Wastewater Reclamation
Microbac	Microbac Laboratories, Inc.
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolts
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NTU	nephelometric unit
OIS	Oil Inspection Section
OPS	Division of Oil and Public Safety
ORP	oxidation reduction potential

OWS	oil water separator
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
ppm	part per million
PRG	preliminary remediation goal
Prudent	Prudent Technologies, Inc.
PVC	polyvinyl chloride
PW	Public Works
QAPP	Quality Assurance Project Plan
QC	quality control
QPP	Quality Program Plan
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
RfD	reference concentration
RfD	reference dose
RI	Remedial Investigation
RL	reporting limit
RME	reasonable maximum exposure
RSL	Regional Screening Level
SAIC	Science Applications International Corporation
SA	skin area
SAP	Sampling and Analysis Plan
SF	slope factor
SI	Site Inspection
SOP	standard operating procedure
SRO	soil remediation objective
Stone & Webster	Stone & Webster Environmental Technology and Services
SVOC	semivolatile organic compound
SW	Space Wing
t_{event}	event duration
TBC	to be considered
TAL	target analyte list
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TEPH	total extractable petroleum hydrocarbons
TIC	tentatively identified compound
TMB	trimethylbenzene
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons

TVPH	total volatile petroleum hydrocarbons
TWG	Technical Working Group
UNCC	Utility Notification Center of Colorado
URS	URS Group, Inc. or URS Corporation
US	United States
USACE	United States Army Corps of Engineers
USAF	United States Air Force
UST	underground storage tank
Versar	Versar, Inc.
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
VRP	Voluntary Remediation Program
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
°C	degrees Celsius
°F	degrees Fahrenheit

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EXECUTIVE SUMMARY

The March 2009 through September 2010 Remedial Investigation (RI) for Site 11 at Buckley Air Force Base (AFB), Colorado, was conducted to characterize identify the sources and extents of volatile organic compound (VOC) contamination identified in two wells in 2006 under a Triad Site Inspection (SI) for the Building 1011 Area of Concern (AOC). A primary objective was to determine whether the groundwater contamination had migrated off base. The site was divided into two primary types and areas of groundwater contamination to be investigated: tetrachloroethene (PCE) detected in well 1011MW06, and four different chlorinated solvents (trichloroethene [TCE]; 1,2-dichloroethane [DCA]; carbon tetrachloride; and chloroform) detected in well 1011MW07. As described below, under this RI, conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the source areas and the extents of the groundwater contamination were determined, and the hydrogeologic conditions were assessed. Removal actions have been conducted to address other previous concerns at Site 11, including lead contamination in soil at the former Building 1011 firing tunnels, contaminated sediment in a sump and sand filter, and petroleum light nonaqueous phase liquid (LNAPL) on groundwater near the southeast end of Site 11.

Site History

As identified in the Triad SI, many potential sources of chlorinated solvent contamination were in the Building 1011 area, based on the previous operations in this area, which began in the early 1940s and continued through the late 1980s or 1990s. These operations included a synchronization area, a base motor pool (also known as transportation and public works [PW] shops), civil engineering (CE) shops, and refueling truck maintenance. Support facilities such as storage, steam heating plant, and latrines, and associated vessels such as underground storage tanks (USTs), oil water separator(s), and septic tank(s) were also present. In 1948, the west end of Building 1011 was expanded for automotive repair. As transportation and PW shops, the various bays or shops included Tire, Body, Auto Paint, Auto Repair, Engine Overhaul, Gas Truck Repair, Tool and Stock Room, Heavy Equipment Repair, Wash and Grease Racks (including a hydraulic lift and floor sump), Buildings and Grounds, Plumbing, Welding and Machine, Electric, Carpenter, and Paint. A 10,000-gallon gasoline UST was associated with Building 719, which was a gasoline station constructed in about 1949. The base motor pool functions moved to another location of the base in 1971; however, the new CE shops were identified as having similar functions, including Carpenter, Electric, Equipment, Paint/Print, Plumbing, Sheet Metal, Battery, Bench Stock, Lawnmower, Wash Rack, Pavements, Welding, Assembly and Construction Equipment Storage, and Generator.

Previous waste materials identified in a Phase I Records Search (Simons, Li & Associates, 1982) described waste material associated with the paint shop as paint, thinner, toluene, and methyl ethyl ketone. The paint was reportedly disposed of at the base dump from 1950 through the late 1960s, and by a contractor after the late 1960s. Beginning in the mid to late 1950s, the other substances were disposed of in a waste oil holding tank (location not specified). Waste materials associated with the plumbing shop included fuel tank sludge and fuel filters, disposed at the base dump through the late 1960s, and by a contractor after the late 1960s. Waste generated by other shops were not specified; they were described as included with

motor pool wastes from another building, which included paint, lacquer thinner, paint remover, hydraulic fluids, stoddard solvent, lubricating oils, and asbestos brake pads. In the late 1980s, Building 1011 contained plumbing, woodworking, and heating shops, and wastes generated at this building were small amounts of lacquer thinner, paint, and paint sludge. A paint spray booth was near the west end of the building. At this time, each building's hazardous wastes were stored in or outside of each building. The building included flammable storage lockers that contained paint, lube oil, propane, rust inhibitor, and thinners.

Investigation Approach

To meet the objectives of the RI, groundwater sampling of previously installed wells, groundwater grab sampling and on-site analysis by a mobile laboratory, temporary and permanent monitoring well installation and sampling, and surface water and sediment sampling were conducted during three primary phases of investigation. A total of 16 wells were installed, three rounds of monitoring well sampling of up to 20 wells for VOCs were conducted, 80 groundwater grab samples were collected from 32 on-base locations and 47 off-base locations and analyzed on-site for six VOCs, three off-base sediment and three surface water samples were collected from East Toll Gate Creek and analyzed for VOCs, and four rounds of water-level measurements were completed. No soil samples were collected for analysis because there was no indication of soil contamination associated with a source area, based on observations for soil continuously collected and screened during well drilling.

The first phase of investigation, conducted in March 2009, included installation of eight monitoring wells, with three wells along the base boundary to address the priority of whether contamination was migrating off base to the west-southwest. Based on the monitoring well data, the contamination did not appear to be migrating off-base at levels above Colorado Basic Standards for Groundwater (CBSGs) (Regulation 41); however, additional investigation was needed in the area of PCE contamination because of uncertainty in the groundwater migration pathway.

The first phase of RI field work indicated direct-push work would be feasible in the downgradient area of the PCE contamination. Therefore, during the second phase of investigation in June 2009, groundwater grab sampling and on-site analysis were conducted to help delineate the extent of on-base PCE groundwater contamination and determine locations for additional monitoring wells. These data indicated a narrow (40 feet wide) dissolved plume of PCE extended off-base at levels above the CBSG. During this second phase of work, five wells were installed on base to monitor the PCE plume, including two wells within the plume, and three in the upgradient area.

The primary focus of the third phase of investigation was to investigate the off-base area. This is a natural area primarily owned by the City of Aurora; therefore, an access plan and agreement were required. Obtaining groundwater data from the north side of the creek, where the PCE plume exited the base, was problematic due to the need to cross the creek, or drive overland about 1.5 miles and cross a deep storm drainage ditch, while adhering to the access conditions stipulated by the City of Aurora. This phase of work was initiated in February 2010; however, only the south side of East Toll Gate Creek could be accessed by the direct-push rig.

The results of the analysis of 24 groundwater grab samples, 3 surface water samples, and 3 sediment samples indicated contamination was not present in or south of the creek above the regulatory standards. In May 2010, the north side of the creek was accessed, and 25 grab groundwater samples were collected and analyzed, and a temporary monitoring well was installed at one location selected to monitor the end of the plume. These data indicated PCE concentrations were above the CBSG in groundwater north of the creek. On-base, two additional wells were installed under a USACE-funded contract. One well was to replace well 1011MW06 in the PCE plume center; the other was to provide an intermediate downgradient well from well 1011MW07. The final round of monitoring well sampling was conducted in June and July 2010, with water levels continuing into September 2010 because they had not stabilized in two of the new wells.

Nature and Extent of Contamination

The RI data indicated there were two distinct dissolved phase plumes of contaminants in groundwater above CBSGs: the PCE Plume and the North Plume. The PCE Plume emanates from a source area south of the east end of former Building 1011 and extends off-base. The smaller North Plume originates in the Building 719 UST area and is characterized by other chlorinated solvents.

The PCE Plume, based on concentrations above the CBSG of 5 µg/L, is about 1,100 feet long, with about 400 feet of the plume off base. The plume is approximately 140 feet wide at the source area, and about 40 to 80 feet wide in downgradient areas where it is influenced by an alluvial paleochannel incised into the Denver Formation bedrock surface. The highest detected PCE concentration was 157 µg/L (well 11MW05); however, the next highest concentration in this well, which was sampled three times during the RI, was 71.5 µg/L. The highest off-base concentration of PCE was 22 µg/L, detected in a groundwater grab sample north of East Toll Gate Creek. PCE was not detected above the CBSG in groundwater samples collected south of the creek or above surface water standards or soil screening levels in samples collected from the creek. Although other VOCs, primarily degradation products of PCE, were detected, none were above CBSGs.

The PCE Plume emanates near a bermed/curbed, asphalt-paved area and migrates to the southwest-west. There may have been spills from potential drums or other containers that may have been near or within the curbed area, or, although no historical information has been found, potentially a subsurface drain line or vessel. The RI well boring data in this area indicate there is not a significant residual source of contaminants in the soil. Former Building 1011 was used for numerous activities that could have used PCE; it was commonly used for metal degreasing. Near the source area, the PCE contamination is in a thick (about 17 feet), weathered, permeable bedrock sandstone about 33 feet below ground surface (bgs). As the PCE-contaminated groundwater migrates downgradient to the southwest-west, it is primarily in a saturated basal alluvial medium- to coarse-grained, loose sand that was deposited within an alluvial paleochannel. The paleochannel was found to extend to a maximum depth of about 35 feet bgs. Groundwater and the base of the paleochannel become shallower in the downgradient plume direction; based on June 2010 water levels, the depth to groundwater was about 27 feet bgs in the upgradient well, and 9 feet bgs in a well at the base boundary. The PCE Plume appears to almost

intersect East Toll Gate Creek west of the base boundary, then it trends to the northwest along the north side of the creek.

The North Plume consists of combined plumes of TCE, 1,2-DCA, carbon tetrachloride, and chloroform, centered about 90 feet south of former Building 1011 below a landscaped area where a 10,000-gallon gasoline UST has been abandoned in place. The highest concentrations of TCE (65.8 μg/L), chloroform (93.8 μg/L), and carbon tetrachloride (140 μg/L), are about an order of magnitude higher than their CBSGs. The most soluble of these solvents, chloroform, has the most widespread distribution above its CBSG, while the other three solvents have remained close to the source at high concentrations. None of these contaminants were detected above CBSGs at the base boundary. The chloroform plume is about 240 feet long and 80 feet wide.

The source of the contamination in the North Plume is within or near the north edge of the gravel landscaped area where well 1011MW07 is located. This area contains a 10,000-gallon UST installed in 1949 to supply fuel for the PW Service Station, and likely taken out of service in the 1970s or 1980s when it was abandoned in place. The source of the VOCs is likely chemicals associated with vehicle repair or other similar activities in former Building 1011. All of the VOCs detected at elevated concentrations are cleaning and degreasing solvents. In addition, chloroform may be present as a degradation product of carbon tetrachloride (which then also degrades to methylene chloride). 1,2-DCA was also used in some paint, varnish, and finish removers. Although 1,2-DCA was also used as a scavenging agent in leaded gasoline to prevent build-up of lead inside fuel-line and motor components, because no other elevated levels of gasoline constituents were present, this source is less likely. Solvents may have been released to the ground by spills, as there are no known utility lines or drains from the auto repair shop. The previous and RI well boring data indicate there is not a significant residual source of contaminants in the soil.

The contaminated groundwater in the North Plume area occurs within weathered bedrock including claystone, siltstone, and minor amounts of sandstone, typically clayey or silty, with low hydraulic conductivity. The most permeable material was observed where the solvent concentrations were highest (well 1011MW07), including a 3-foot-thick wet, loose, fine- to medium-grained sandstone. At this location, bedrock underlies fill material that extends to a depth of about 18 feet bgs. In June 2010, the groundwater level was about 24 feet bgs. The permeable sandy fill material surrounding this UST has likely contributed to the migration of contaminants in this immediate area, both laterally and vertically. However, in the upgradient and downgradient wells, there is not a consistent/continuous or identifiable water-bearing zone, and the bedrock in this area does not readily yield water, which has limited the migration of contamination.

Fate and Transport

The primary route of migration of the Site 11 groundwater contaminants is through downgradient (horizontal) migration of VOCs dissolved in groundwater. The boundaries and preferential pathways for migration of groundwater are well defined, particularly in the areas of PCE contamination where the direct-push work was conducted. Migration of PCE to deeper

water bearing zones does not appear to be a migration pathway of concern; groundwater contamination in the source area is in a weathered bedrock sandstone, and migrates downgradient in and near the bottom of the saturated alluvium in an alluvial paleochannel. At the North Plume area, the contaminants have remained close to the source area in bedrock groundwater, and vertical and horizontal migration is limited due to the thin, discontinuous water-bearing zones with apparent low hydraulic conductivity. The most widespread contaminant in the North Plume area is chloroform, potentially because it has the highest water solubility of the solvents of concern in this area.

The contaminants in groundwater at the North Plume area have not migrated off base at levels above the CBSGs, and an assessment of contaminant persistence, including apparent degradation of carbon tetrachloride to chloroform and methylene chloride, indicates it will likely be similarly limited in the future. In contrast, to the south, PCE has migrated off base above the CBSG of 5 μg/L in the groundwater, to the southwest to west. The migration of PCE through the site has been primarily controlled by an alluvial paleochannel. The PCE-impacted groundwater has discharged to East Toll Gate Creek to a limited extent; however, the concentrations of PCE and its degradation products in the surface water and sediments in East Toll Gate Creek are low compared to the water standards and soil screening levels. Off base, the creek appears to alternately gain and lose water. Degradation of PCE is occurring at the off-base portion of the plume near East Toll Gate Creek. The creek appears to be impacting degradation of the PCE, potentially by several routes, including volatilization/oxygenation, decaying organic matter, root activity, and plant uptake. Based on the presence of degradation products and likelihood for this natural degradation to continue, the groundwater and surface water interaction, and the apparent preferential contaminant migration pathway, the PCE is not likely to migrate across (south of) the creek or significantly farther downgradient at high concentrations in the future.

The Site 11 groundwater plumes are not expected to migrate to or impact domestic or municipal drinking water wells; there are no domestic or municipal drinking water wells within at least 1 mile of Site 11. The contaminated groundwater does not underlie any buildings on base or off-base, and it is not migrating toward off-base structures, so it is not expected that vapor from the groundwater plumes would migrate into existing structures. The closest structures are the Foxdale Condominiums, which are off base, cross-gradient from the plume, about 250 feet to the south (at the closest point). The area west of the base along East Toll Gate Creek is managed as a natural area by the City of Aurora Parks and Recreation; there are no improvements on the property. It is unlikely buildings would be constructed over the plumes in the future.

Risk Assessment

A baseline human health risk assessment (HHRA) was performed for Site 11 to determine whether the VOCs detected in groundwater, surface water, and sediment might pose a threat to human health. PCE and low levels of other VOCs have migrated off base in groundwater, but are not expected to have the potential to impact domestic or irrigation wells. Because there are no buildings above or near the current contaminant plumes, migration to

indoor air is not currently a concern. VOC-impacted groundwater from a portion of the plume has discharged to an off-base segment of East Toll Gate Creek.

The current use of the on-base portion of Site 11 is as a storage and staging area for base construction. No future building is expected in this area; the Site 11 area south of Aspen Way, along East Toll Gate Creek, may be developed as part of a golf course. The current use of the off-base portion of Site 11 is an unimproved open space area. The primary off-base users are recreators, primarily residents of the housing complex to the south (Foxdale Condominiums). City of Aurora personnel are expected to also periodically access the area south of the creek for mowing.

The Baseline HHRA indicated for the current potential uses and receptors of the Site 11 plume areas, estimated cancer risks are not above the United States Environmental Protection Agency's (EPA) lowest and the Colorado Department of Public Health and Environment (CDPHE) target level of $1x10^{-6}$, and non-cancer effects are not expected. This is based on evaluation of current off-base visitors and maintenance workers who may contact the surface water and sediment in East Toll Gate Creek. It is also based on a potential construction worker who may inhale vapors from groundwater in a trench, and, for off-base work, because the groundwater is shallower, may also be exposed to groundwater through incidental ingestion and dermal contact. There are no known completed direct exposure pathways to human receptors from groundwater within the currently defined extent of groundwater contamination described in this RI.

Although no construction of commercial buildings over the on-base Site 11 plumes is planned, in the future, if a commercial building is constructed, occupants may be exposed to the groundwater contaminants through inhalation of vapors in indoor air. Additionally, although highly unlikely, they may use the groundwater for drinking water. Under this scenario, the reasonable maximum exposure (RME) cancer risks for both the North Plume and On-Base PCE Plume exceed the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. However, for the indoor air pathway, which is the most likely exposure pathway under this scenario, the risks ($1.36x10^{-6}$ and $1.08x10^{-5}$, respectively) are within EPA's risk range of 10^{-6} to 10^{-4}, although they exceed CDPHE's target cancer risk of $1x10^{-6}$. Non-cancer effects are not expected.

Even less plausible for the Site 11 on-base and off-base plume areas, is the scenario that residents would occupy houses over the plumes, and use the groundwater for drinking water and showering/bathing. In addition, these hypothetical residents could be exposed to vapors in indoor air from the groundwater. Under this scenario, for all the Site 11 plume areas, the RME cancer risks for the sum of all three exposure pathways for lifetime residents are above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. Of these, the indoor air exposure pathway has the lowest risk, ranging from $6.84x10^{-6}$ (On-Base PCE Plume) and $8.30x10^{-6}$ (Off-Base PCE Plume), to $5.44x10^{-5}$ (North Plume). Non-cancer hazard indices (HIs) for the On-Base PCE Plume and the North Plume, 1.31 and 4.71, respectively, slightly exceed the target HI of 1.0, indicating potential non-cancer health effects if the groundwater is used for drinking water by residents.

Based on assessment of risk associated with exposure to groundwater, sediment, and surface water, the following chemicals associated with previous site operations are found at levels that may pose an unacceptable risk to potential future human populations:

On-Base PCE Plume:

- PCE in groundwater

Off-Base PCE Plume:

- PCE and TCE in groundwater

North Plume:

- Carbon tetrachloride, chloroform, 1,2-DCA, and TCE in groundwater.

Conclusions and Recommendations

The contaminants in groundwater at the North Plume area have not migrated off base at levels above the CBSGs, and the assessment presented in this report indicates the extent will likely be similarly limited in the future. Degradation of carbon tetrachloride to chloroform and methylene chloride by reductive chlorination appears to be occurring, potentially helped by low levels of cometabolites in the form of petroleum hydrocarbons at the UST area. However, additional monitoring is recommended to verify concentration changes over time.

In contrast, in the southern area of the site, PCE has migrated off base above the CBSG of 5 µg/L in the groundwater, to the southwest to west. The PCE-impacted groundwater has discharged to East Toll Gate Creek to a limited extent; however, the concentrations of PCE and its degradation products in the surface water and sediments in East Toll Gate Creek are low compared to the water standards and soil screening levels. Degradation of PCE is occurring at the off-base portion of the plume near East Toll Gate Creek. The creek appears to be impacting degradation of the PCE, potentially by several routes, including volatilization/oxygenation, decaying organic matter, root activity, and plant uptake. Based on the presence of degradation products and likelihood for this natural degradation to continue, the groundwater and surface water interaction, and the apparent preferential contaminant migration pathway, PCE is not likely to migrate across (south of) the creek or significantly farther downgradient at high concentrations in the future, based on these ongoing conditions.

There are no current exposure pathways to the contaminated groundwater and future exposure pathways are not likely. The area west of the base along East Toll Gate Creek is managed as a natural area by the City of Aurora Parks and Recreation; there are no improvements on the property. However, recreators or potential maintenance workers may be exposed to surface water or sediment in the creek. The Site 11 contaminated groundwater does not underlie any buildings on base, and it is not near off-base structures; the existing buildings are too far away to be impacted by vapor from the groundwater plumes. However, additional groundwater monitoring is recommended to verify concentration changes over time.

The baseline HHRA indicated exposure to contaminants in surface water and sediment in East Toll Gate Creek, and potential exposure to contaminated groundwater by potential construction workers when digging an excavation or a trench do not present elevated levels of risk. Estimates of cancer risks for these scenarios are not above EPA's lowest target risk level and CDPHE's target level of $1x10^{-6}$, and non-cancer effects are not expected. Under potential, although unlikely, future scenarios (e.g., residential use, use of groundwater as drinking water), occupants of future on-base commercial buildings or on-base or off-base residences that are constructed over the plumes, may be exposed to the groundwater contaminants through inhalation of vapors in indoor air. In addition, although highly unlikely, they may use the groundwater for drinking water. Under these scenarios, the estimated cancer risks for both the North Plume and On-Base PCE Plume exceed the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. However, for the indoor air pathway, which is the most likely potential exposure pathway under these scenarios, the risks are within EPA's risk range of 10^{-6} to 10^{-4}, although they exceed CDPHE's target cancer risk of $1x10^{-6}$. Potential non-cancer health effects could occur if the groundwater is used for drinking water by residents. Based on the assessment of risk associated with exposure to groundwater, sediment, and surface water, the following chemicals associated with previous operations at Site 11 are found at levels in groundwater that may pose an unacceptable risk to potential future human populations: PCE, TCE, carbon tetrachloride, chloroform, and 1,2-DCA.

This RI report marks the completion of the RI phase of the CERCLA process for Site 11 groundwater. The Feasibility Study (FS) phase will address remedial evaluations and design, and collection of supplemental data as appropriate to help ensure that appropriate and effective remedial measures for the chlorinated solvent groundwater plumes are implemented. No additional remedial actions or monitoring are warranted for the petroleum LNAPL near the southeast end of Site 11, and discontinuance of this program is recommended.

The following remedial action objectives (RAOs), which are medium-specific goals for protection of human health and the environment, are proposed for the Site 11 chlorinated solvent groundwater plumes:

- Prevent ingestion of and direct contact with impacted groundwater until concentrations have been reduced to levels that allow unrestricted use and unlimited exposure (i.e., CBSGs or maximum contaminant levels [MCLs])

- Prevent vapors that may originate from impacted groundwater from accumulating to unacceptable levels in indoor air of potential future buildings

- Restore groundwater to beneficial use, where restoration means reducing concentrations of contaminants in groundwater to their respective CBSGs or MCLs via engineered and/or natural processes.

As described above, regular monitoring of the Site 11 wells for the two plume areas is recommended to assess concentration trends for the VOCs of concern over time, for both on-base and off-base groundwater. Monitoring for natural attenuation parameters may also be warranted to assess biodegradation processes acting on chlorinated solvent contamination in

groundwater at Site 11, and support whether further study or evaluation should be considered. As needed to support remedy evaluation, collection of additional hydrogeologic, physical, and chemical data may be warranted, such as in the source areas or near the base boundary.

1.0 INTRODUCTION

This report documents the results of the Remedial Investigation (RI) conducted from March 2009 through September 2010 at Installation Restoration Program (IRP) Site 11 (Building 1011 Area) at Buckley Air Force Base (AFB), Aurora, Colorado. This work was performed by Versar, Inc. (Versar) and Prudent Technologies Inc. (Prudent) under Contract Number FA8903-08-D-8794, Task Order 0003, for the Air Force Center for Engineering and the Environment (AFCEE), and generally follows United States (US) Environmental Protection Agency (EPA) guidance for performing RIs under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA, 1988).

This RI addresses chlorinated solvent contamination previously detected in groundwater from two wells in separate areas of Site 11. The Colorado Department of Public Health and Environment (CDPHE) considered this investigation a high priority because of the potential for the groundwater contamination to migrate off base. The scope of this investigation included installing monitoring wells; collecting and analyzing groundwater, surface water, and sediment samples; and monitoring water levels. The work was conducted in accordance with the *Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar and Prudent, 2009a) and two addenda to the Final Quality Program Plan (QPP) (Versar and Prudent, 2009b, 2009c).

1.1 THE US AIR FORCE ENVIRONMENTAL RESTORATION PROGRAM

The objective of the US Air Force Environmental Restoration Program (ERP), a division of which is the IRP, is to assess past hazardous waste disposal and spill sites at Air Force installations and to develop remedial actions consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for sites that pose a threat to human health and welfare or the environment.

The ERP program at Buckley AFB began in the early 1980s, with initiation of the Phase I Records Search (Simons, Li & Associates, Inc., 1982). Buckley AFB is not a National Priority List (NPL) site; however it is Air Force policy to address ERP sites in a manner consistent with CERCLA guidance and policy and subject to substantive requirements of other environmental protection laws.

1.2 INSTALLATION DESCRIPTION

Sections 1.2.1 through 1.2.6 describe the operational history, physical setting, climate, surface water, geology, and groundwater hydrology of Buckley AFB. Site-specific information for Site 11 is described in Section 3. The environmental setting information for Buckley AFB is primarily from the Phase II Confirmation/Quantification Stage 1 (Dames & Moore, 1986); the RI Report for Buckley Air National Guard (ANG) Base ("Basewide RI Report") (Science Applications International Corporation [SAIC], 1995); the Sites 2 and 3 Groundwater Monitoring Technical Memorandum (Stone & Webster Environmental Technology and Services [Stone & Webster], 1999); and the Basewide Environmental Baseline Survey (EBS) (AFCEE, 2000).

1.2.1 Operational History

Buckley AFB occupies approximately 3,250 acres within the City of Aurora and Arapahoe County, Colorado, and is located approximately 4.5 miles east of Denver, Colorado (Figure 1-1). Since the federal government's initial possession of the property in 1942, the base has been owned by three US Department of Defense (DOD) organizations, including the US Army Air Corps initially, the US Navy from about 1947 through 1959, and the US Air Force to the present. The Colorado ANG had a permit from the Navy and a license from the Air Force to use and act as the host of the property until 2000. The host-base responsibility was reassigned from the ANG to Air Force Space Command (AFSPC) effective October 1, 2000. The 460th Space Wing (SW) currently controls the installation. The following paragraphs describe the history of the base in more detail, as summarized from the Management Action Plan (AFSPC, 2002).

In 1942 and 1943, the federal government purchased 5,740 acres of land outside Denver, Colorado, and designated it as Buckley Field. Buckley Field was used to train US Army Air Corps B-17 and B-24 bombardiers and armorers, and to conduct basic and arctic training. In 1946, the Army deactivated Buckley Field and transferred its ownership to the State of Colorado. The Colorado ANG then occupied Buckley Field and conducted training for ANG personnel.

In 1947, the US Navy assumed control of a portion of Buckley Field for use as a training area and renamed it Naval Air Station (NAS) – Denver, Colorado. The remainder of the field was left in the control of the Colorado ANG.

In 1959, the Navy deactivated the station, and transferred the property to the Colorado ANG. The station was then renamed Buckley ANG Base, and used for military aviation and support activities.

Effective October 1, 2000, when the base was reassigned from the ANG to AFSPC, the 821st Space Group became the host group. In October 2001, the 460 Air Base Wing (ABW) was established at Buckley AFB and assumed control of the installation. In August 2004, the ABW became a Space Wing. The SW supports the Air Force mission by providing space-based missile warning data, space communication data, and data relay operations, as well as sustaining all related base support functions. The 460 SW at Buckley AFB acts as a host unit for military units in the Denver area. There are over 20 tenant organizations on the base.

In support of its past missions of combat training, transient aircraft support, and search and rescue response, the base has stored and used various types of hazardous materials during its history. Although some of the base's historical operations have resulted in the storage and use of hazardous materials, not all of these operations relate to ERP or IRP sites. Since the early 1980s, a substantial amount of investigation has been completed to characterize the nature and extent of contamination and assess and implement response actions for these sites. Site 11 is the most recently identified of the 11 IRP sites at Buckley AFB. It was previously investigated as the Building 1011 Area of Concern (AOC).

1.2.2 Physical Setting

Buckley AFB is located within the City of Aurora and Arapahoe County, Colorado, within the Denver metropolitan area (Figure 1-1). Buckley AFB is bounded by 6th Avenue on the north and northeast, Gun Club Road and E-470 to the east, Jewell Avenue on the south, and Buckley Road/Airport Boulevard to the west. Site 11 is located in the southwest portion of Buckley AFB, south of A-Basin Avenue, west of Aspen Street, north of Mississippi Avenue, and east of Alameda Parkway (Figure 1-2). The off-base areas to the west and south of Site 11 include single and multi-family residential housing, commercial development, and open space along East Toll Gate Creek.

Denver and Buckley AFB are located along the western edge of the Great Plains physiographic province, which terminates west of the base at the Front Range of the Rocky Mountains. The base is located in an area of grass-covered rolling uplands, generally developed on eolian (loess) and alluvial deposits.

The topography in the Buckley AFB vicinity consists of gently rolling hills separated by broad valleys. The base is on a broad northwest-trending ridge, bordered on the southwest by a northwest trending intermittent drainage (East Toll Gate Creek) and on the northeast by a north trending intermittent drainage to Sand Creek (Figure 1-2). The ground elevation ranges from about 5,500 to 5,700 feet. The highest point is located near the southeast corner of the base, and the lowest areas are within the drainages near the base boundaries.

1.2.3 Climate

The following climate and meteorological information is primarily from the Sites 2 and 3 Groundwater Monitoring Technical Memorandum (Stone & Webster, 1999). The climate in the area is semi-arid, with the average annual rainfall equal to 16.65 inches. Over 75 percent of the precipitation falls between March and September, and monthly average precipitation ranges from 0.47 inches in January to 2.68 inches in May. The average annual snowfall in the area is 51.8 inches. The average annual evaporation rate is approximately 45 inches per year. The average annual temperature is approximately 49.7 degrees Fahrenheit (°F), with the average monthly temperature ranging from 30°F during January, to 72.1°F during July. Prevailing winds are from the south at an average annual speed of 9 miles per hour. The highest intensity winds come from the north, northwest, west-northwest, and can exceed 24.7 miles per hour (URS Group, Inc. [URS], 2004a).

1.2.4 Surface Water

There are two primary surface water drainage areas within the vicinity of Buckley AFB, Toll Gate Creek and Sand Creek. The drainage divide between East Toll Gate Creek and Sand Creek corresponds to the main northwest/southeast runway at the base. Site 11 is within the East Toll Gate Creek drainage area, which primarily drains agricultural and residential areas. East Toll Gate Creek flows toward the northwest, through the southwest corner of Site 11, and is a tributary to Sand Creek, discharging northwest of the base (Figure 1-1). Sand Creek maintains a small base flow throughout most of the year, and discharges to the South Platte River. On

Buckley AFB, East Toll Gate Creek is normally dry, and only flows during or immediately after precipitation events. Immediately downstream of the Buckley AFB boundary, water is more consistently present in portions the creek, partially because of a tributary from the south, and also likely partially from groundwater discharge, as discussed in Section 3.2.

The Federal Emergency Management Agency (FEMA) has designated the East Toll Gate Creek drainage as a 100-year floodplain (AFCEE, 2000). The regulatory floodplain has been defined east of Buckley AFB and is being updated downstream (west) of Buckley AFB. In addition, Buckley AFB recently delineated the 100-year and 500-year flood plains for East Toll Gate Creek through Buckley AFB, continuing from off-base FEMA-mapped areas (Merrick & Company, 2006), as shown on Figure 1-3. The southwest portion of the Site 11 investigation area is within the floodplain for East Toll Gate Creek, and includes an off-base segment of the creek.

Buckley AFB has six areas that have been designated as wetlands by the US Fish and Wildlife Service, and was reported to contain at least five additional potential wetlands areas (AFCEE, 2000). In 2004, eight wetland areas, delineated following the standard US Army Corps of Engineers (USACE) delineation methodology, the accepted method for Clean Water Act (CWA) Section 404 jurisdictional wetland determinations, were identified within the banks and channel of East Toll Gate Creek within Buckley AFB (Versar, 2007a). Wetlands have not been mapped within or immediately adjacent to Site 11, based on the US Fish and Wildlife Service inventory and Buckley AFB evaluations; however, this area may not have been subject to a detailed analysis.

1.2.5 Geology

Buckley AFB is located within the Denver Basin geologic structure, which consists primarily of interbedded shale, claystone, siltstone, and sandstone, ranging from Late Cretaceous to Early Tertiary in age. Sedimentary rocks within the basin are comprised of seven geologic formations. In descending order, these formations are the Castle Rock Conglomerate; Dawson Arkose; the Denver, Arapahoe, and Laramie Formations; the Fox Hills Sandstone; and the Pierre Shale. The Castle Rock Conglomerate and the Dawson Arkose are not present in the Buckley AFB area. At Buckley AFB, the Denver Formation crops out, or is overlain by Quaternary-age unconsolidated alluvial and eolian deposits. The Denver Formation is approximately 850 feet thick in the Buckley AFB area, and crops out along the northeastern, east, and southwest areas of the base. At Buckley AFB, the formation consists of variable consolidated, fractured and unfractured, interbedded claystone, siltstone, and fine to coarse grained sandstone, with occasional coal seams, that occur in discontinuous lenticular beds. It is characterized by its brown, olive, green-gray, bluish-gray, and tan colors, derived from basaltic and andesitic source rock. At the contact with the alluvium, varying lithologies of the Denver Formation are present. This occurs because of the discontinuous lenticular bedding and also because the bedrock surface is an erosional surface, shaped by stream processes.

The alluvial deposits are confined to stream valleys, which generally trend southeast to northwest along the southwest and northeastern sides of the base. The alluvial deposits have a maximum thickness in the central portions of the valleys and decrease in thickness along the

flanks. Because these deposits are derived from the Denver Formation, these deposits have similar characteristics to the Denver Formation, except the material is unconsolidated and tends to be coarser and more homogeneous. The eolian (windblown) deposits are typically unconsolidated silt, sandy silt, silty clay, and fine to medium grained silty sand, and, in the central portion of Buckley AFB, range up to 30 feet thick in the topographically high areas relative to the stream valleys. For purposes of this document, eolian deposits and alluvium are collectively referred to as alluvium.

1.2.6 Groundwater

Three principle bedrock aquifers comprise the Denver Basin within the Buckley AFB area. In descending order, these aquifers are the Denver, Arapahoe, and Laramie-Fox Hills aquifers. The Denver aquifer materials consist of variable consolidated sandstones, siltstones and conglomerate deposits. Flow within the Denver aquifer in the Buckley AFB area is to the north-northwest, toward the South Platte River where the aquifer crops out. Regional recharge to the Denver Formation is from direct infiltration of precipitation, irrigation water in highland areas, and downward leakage in upland reaches of stream and river valley alluvial aquifers. Recharge to the alluvial aquifer is through direct infiltration of precipitation and irrigation water and by lateral and upward seepage of groundwater in downstream reaches of valleys. Groundwater discharge of the alluvial aquifer is primarily through evapotranspiration, seepage to streams, and downward seepage into underlying bedrock aquifers. Groundwater flow in the alluvial aquifer is generally downstream and toward the stream channel.

Local water-bearing strata at Buckley AFB are comprised primarily of the Denver and the alluvial aquifers. The local groundwater potentiometric surface at Buckley AFB generally follows land surface topography. Water in the Denver aquifer exists under confined, semi-confined, and unconfined conditions. Water in the alluvial aquifer is typically unconfined. The alluvial and shallow, weathered bedrock water-bearing zones tend to act as a single aquifer. The contact between the alluvial and bedrock is an erosional unconformity, and a weathered or fractured zone in bedrock is typically present at this interface.

No commercial or domestic wells are near the area. Buckley AFB obtains all of its potable water from the city of Aurora, and there are no downgradient off-base wells for domestic or commercial use within at least 1 mile of the site (AFCEE, 2000). Further information regarding wells near Site 11 is presented in Section 4.3.

1.3 SITE INVENTORY/PAST ERP WORK

Site 11 was identified as an AOC, the Building 1011 Complex, in the Draft Basewide Preliminary Assessment (PA) (URS Group, Inc. [URS], 2005a). This was based on historical research that indicated potential environmental concerns in this area, in addition to information from other investigations, conducted from 2004 to 2005, as described in this section. This information indicated additional assessment of the area was warranted. A Triad Site Inspection (SI) for this AOC was completed in 2007 (Versar, 2007b). Because groundwater contamination at the site warranted an RI, the AOC was converted to IRP Site 11.

This RI has been conducted to assess the remaining concern at Site 11, groundwater contaminated by chlorinated solvents underlying and downgradient of the site, as recommended in the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b). Removal actions to address lead contamination in soil at the former Building 1011 firing tunnels and to remove a sump and sand filter with sediment contaminated with tetrachloroethene (PCE), trichloroethene (TCE), and polynuclear aromatic hydrocarbons (PAHs) have been completed. A removal action for petroleum light nonaqueous phase liquid (LNAPL) has also been conducted. These actions are documented in the *Final Engineering Evaluation/Cost Analysis for Site 11 Soil and Petroleum LNAPL* (Versar, 2008a); the *Final Site 11 (Building 1011) Soil Action Memorandum* (Versar, 2008b); and the *Final Completion Report for Site 11 (Building 1011 Area) Soil Removal Action* (Versar and Prudent, 2010). In addition, the Air Force has continued to monitor the LNAPL, as described in Section 1.3.2.10.

A history of the Site 11 area and previous investigative activities and findings are presented below in Sections 1.3.1 and 1.3.2, respectively. Because of the complexity and relationships of the site uses, all areas and previous investigations of the Site 11 area are described. These discussions are primarily from the Triad SI QPP and Report, updated to include current information.

1.3.1 Site History

Previous operations in this area, beginning in the early 1940s, have included a synchronization area, a base motor pool (also known as transportation and public works [PW] shops), civil engineering (CE) shops, and refueling truck maintenance, including support facilities such as storage, steam heating plant, and latrines, and associated vessels such as underground storage tanks (USTs), oil water separator(s) (OWS), and septic tank(s). There are no existing buildings within Site 11 and no current routine uses; however, several former buildings or structures, as described below and listed in Table 1-1, were located in this area. Activities associated with each of these structures are discussed in the following subsections. Additional supporting documentation is in the appendices to the *Final Quality Program Plan Triad Site Inspection for Building 1011 Area of Concern, Buckley Air Force Base* (Versar, 2006) and the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b).

Figure 1-4 shows the former buildings and investigated potential contaminant source areas, and Figure 1-5 is a 1971 aerial photograph of the site and adjacent areas, which indicates locations of other buildings described in the following sections. This section summarizes known information about contaminant sources and contamination at the Site 11 (Building 1011 complex), based on past operations and waste disposal practices and previous investigations.

1.3.1.1 Building 709/1012: Latrine/Storage

Building 709 (renumbered 1012) was constructed as a sanitary latrine prior to July 10, 1959, based on aerial photo review (although other documents indicate it was constructed in 1967). It was an 11.6- by 22-feet structure. Recent Buckley AFB utility maps show this building was connected to the septic tank south of Building 710, which appeared to drain to a leach field near the Site 2 Oil Pit. This septic tank was closed in 1995 (Section 1.3.2.8).

Although no historical maps have been found that indicate another septic tank, holding tank, or leach field was present, and no other leach fields have been observed on historical aerial photographs, interviewees have referred to a septic tank without a leach field (holding tank) and also a former leach field to the west of the leach field near Site 2 (Versar, 2007a; October 21, 2004 interview). Therefore, it is possible wastewater from Building 1012 may have drained to a potential other septic or holding tank (and potential leach field) that may have been removed. If present, the location may correspond to the terminus of a wastewater line near Aspen Way shown on a Buckley AFB utility map (Figure 1-4). The Draft Basewide EBS (AFCEE, 2000) identified Building 709 (1012) as including flammable storage lockers used for storage of paint, thinners, and removers, and indicated it was connected to an OWS. This OWS may be the one that was south of Building 710, connected to the septic tank, and previously removed, as described below. Building 1012 was removed in August through September 2005.

1.3.1.2 Building 710: Refueling Truck Maintenance

Building 710, constructed in 1961, was a Quonset hut where maintenance was performed on trucks that delivered jet fuel to the flight line, and associated drains were reportedly connected to an OWS south of the building. A Sergeant at Buckley AFB who worked at this building from 1986 to 1992 indicated they stored JP-4, JP-8, Avgas, gasoline, diesel fuel, PD680 degreasing solvent (for parts washing), and possible waste fuels and oils in and around the building (January 7, 2005 interview by a Buckley AFB contractor). This interviewee indicated JP-4 and JP-8 were stored in drums outside and east of Building 710 beginning in about 1986, PD680 was stored in a 200-gallon above-ground storage tank (AST) at the southwest end of the building, and, prior to 1986, JP-type fuels and possible waste fuels and oils were stored in drums contained in surface pits east of the building. A base employee working for the CE mechanical shop indicated used oil filters were air dried and stored in these drums (personal communication with Versar, April 2006). The Sergeant stated concrete pads were east and west of the building and in the central building area, and the east and center pads had floor drains. However, a 1992 report by ATEC Associates, Inc. (ATEC), discussed in Section 1.3.2.2, indicates the west pad (rather than the center pad) and the east pad had drains connected to the OWS. One of the adjacent structures was Building 718, present from 1974 to 1994. A Buckley employee who worked at Building 710 beginning in about 1993 indicated, in an October 27, 2004 interview (Versar, 2007a), that used oil was not disposed of in the drains, and may have been taken to the old motor pool at Building 640. Building 710 was removed in 1994, and the Sergeant indicated it was dismantled and taken off site.

The Sergeant who worked at Building 710 from 1986 to 1992 believed that at least two floor drains gravity drained to a poorly-maintained circular OWS within about 20 feet south of the westernmost corner of the building, and this OWS drained to the "OWS" (septic tank) about 100 feet south and transferred waste from Building 1011 to the leach field near the IRP Site 2 oil pit. The Buckley employee who worked at Building 710 beginning in about 1993 indicated that they periodically had this vessel (likely the septic tank) pumped out (Versar, 2007a; October 27, 2004 interview). This information is generally consistent with the Site Plan included in the 1992 ATEC report; the OWS is shown south of the west corner of Building 710, connected to two floor drains in the outer pads of the building, and connected to the septic tank to the south. Another current Buckley AFB employee thought that one OWS north of Aspen Way and the

leach field was removed, another one remains, and a septic tank is north of the remaining "OWS" (Versar, 2007a; October 21, 2004 interview). However, based on work implemented in 1995 to close the remaining structure (location identified by two lids about 30 feet apart), it appeared to be a large multi-chambered septic tank, as described below in Section 1.3.2.8. These observations are consistent with the Draft Basewide EBS (AFCEE, 2000), which reports a septic tank with a 10,000-gallon capacity was connected to Building 710, and consistent with the Phase I Records Search (Simons, Li & Associates, 1982), which states that industrial wastewaters were pretreated by an OWS at Building 710 before they discharged to a septic tank. According to the Phase I Records Search, separated oil and grease were contained in holding tanks that were periodically pumped to 55-gallon drums and sent to supply for reclamation. The 1992 ATEC report indicates an oil storage UST/holding tank was immediately southwest of the OWS. An Installation Map dated February 15, 1994, indicated an OWS (unknown capacity) at Building 710 was inactive, with a planned project to "pump, abandon, and tie off." During the test pit digging performed under the Triad SI in May 2006 (Section 1.3.2.9), a concrete structure (potentially containment for the oil storage UST) and a circular metal lid (but no OWS) were found in the general locations indicated on the 1992 ATEC drawings.

As described in Section 1.3.2.4, south of former Building 710, about 5 feet south of where the Building 710 OWS was thought to exist, in October 2004, a monitoring well (MW710-1) was found to contain petroleum product floating on top of groundwater. In December 2004, about 10 inches of product was present, and laboratory analysis indicated it was jet fuel mixed with a heavy oil, such as motor oil or hydraulic fluid. One of the three primary investigations conducted under the Triad SI focused on the source and extent of the petroleum LNAPL and potential associated dissolved plume, as described in Section 1.3.2.9. A removal action for the LNAPL has been conducted, as described in Section 1.3.2.10.

1.3.1.3 Building 711/1011: Synchronization Shed, Motor Pool, CE Shops

Building 711 (renumbered 1011), in addition to adjacent Buildings 712 through 717, was constructed in 1942 and used for synchronizing activities through about 1947 (URS, 2003). Building 711 was a 625- by 30-feet concrete block structure. An interview conducted under the Initial PA (URS, 2003) indicated below-ground tunnels in the building were used to test fire machine guns. Although another interviewee who began working in Building 711 in 1985 mentioned possible larger caliber ammunition (howitzers) were fired into the tunnel, physical and visual evidence of the near-surface soil and impact area indicates only .50 caliber or smaller ammunition were used in the tunnel (URS, 2005b). Synchronization refers to the timing of firing of rounds so they do not strike the airplane propellers. A plan for the building shows 30 cells (or bays), and a central tool room and maintenance room. In each bay of the building, a port in the northeast wall opened into a cinderblock (concrete block)-lined tunnel through an earthen berm that extended the length of and adjacent to the building. A large gun was bolted to the floor of each bay and fired into the tunnel. Another plan for the building shows a 1,000-gallon gasoline UST on the north side of the center of the building. The gasoline was used to fuel the engines for the propellers. This UST was uncovered during trenching activities in February 2005, as described in Section 1.3.2.9, investigated under the Triad SI, and no contamination was observed or detected in soil in the adjacent boring.

A December 30, 1948, NAS drawing of the PW Service Station indicates the west end of Building 711 was used for automotive repair, and a grease rack was near the center of the building. After the use of Building 711 as a synchronization shed, the back of the automotive repair bay was extended 12 feet to the north (and at least two firing tunnels removed), based on a June 7, 1948, NAS drawing. Other NAS drawings from the 1950s (December 27, 1951; June 8, 1954; and February 28, 1955) indicate Building 711 was the transportation and PW shops. From west to east, the various bays were identified as Tire Shop, Body Shop, Auto Paint Shop, Auto Repair Shop, Engine Overhaul, Gas Truck Repair, Tool and Stock Room, Heavy Equipment Repair, Wash and Grease Racks (including a hydraulic lift), Locker Room, Shops, Stores, Buildings and Grounds, Plumbing Shop, Welding and Machine Shop, Electric Shop, Carpenter Shop, and Paint Shop. Building 711 was later used for the Colorado ANG motor pool until about 1971 when Building 940 was built (URS, 2003), and the CE shops moved into Building 711.

The Phase I Records Search (Simons, Li & Associates, 1982) described waste material associated with the Building 711 paint shop as paint, thinner, toluene, and methyl ethyl ketone (MEK). The paint was reportedly disposed of at the base dump from 1950 through the late 1960s, and by a contractor after the late 1960s. Beginning in the mid to late 1950s, the other substances were disposed of in a waste oil holding tank (location not specified). Waste materials associated with the Building 711 plumbing shop included fuel tank sludge and fuel filters, disposed at the base dump through the late 1960s, and by a contractor after the late 1960s. Waste generated by other shops at Building 711 were not specified; they were described as included with the Building 940 motor pool wastes, which included paint, lacquer thinner, paint remover, hydraulic fluids, stoddard solvent, lubricating oils, and asbestos brake pads.

From about 1971 through the late 1980s or 1990s, Building 711 contained various CE shops, including Carpenter, Electric, Equipment, Paint/Print, Plumbing, and Sheet Metal shops (Simons, Li & Associates, 1982). December 1981 drawings indicate the uses of the bays were similar to the uses identified during the Naval era. From west to east, the bays included a Paint Shop, Office, Flight Area, Flight Storage, Battery Shop, Storage, Bench Stock, Lawnmower Shop, Wash Rack, Storage, Break Room, Pavements, Plumbing Shop, Welding Shop, Electric Shop, Carpenter Shop, and Storage. On a June 22, 1988, drawing, the uses were similar, although the Flight Area and Flight Storage were identified as Assembly and Construction Equipment Storage, the Bench Stock was identified as Administrative Offices, Pavements was the 140th Offices, and Storage was a Generator Shop. A floor sump was shown on the west side of the Wash Rack area.

During a January 13, 1987, Hazardous Waste Inspection by the Colorado Department of Health (CDH) Hazardous Materials and Waste Management Division (CDH, 1987), a Buckley representative stated Building 711 contained plumbing, woodworking, and heating shops, and wastes generated at this building were lacquer thinner, paint, and paint sludge in small amounts. At this time, each building's hazardous wastes were stored in or outside of each building. An interview conducted under the Initial PA (URS, 2003) indicated there was a paint spray booth in Building 711. A June 22, 1988, drawing shows a spray booth near the west end of the building. The Draft Basewide EBS (AFCEE, 2000) identified the building as including flammable storage lockers that contained paint, lube oil, propane, rust inhibitor, and thinners.

Prior to demolition in August through September 2005, Building 1011 was used for storage. The foundation and portion of the back (north) wall of this building remain and have been covered with soil. A removal action to address contaminated soil at the former firing tunnels, the floor sump, and an outside sand filter has been completed (Section 1.3.2.10).

1.3.1.4 Buildings 712 and 713: Latrine and Storage

Buildings 712 and 713 were small buildings northeast of Building 711 (Building 713 was 26 by 20 feet). Building 712 was originally constructed as a lavatory/latrine, and Building 713 was a vault (specifically identified as a machine gun vault in a 1945 plan, and as paint storage in 1959 and 1983 plans). Building 712 was used for storage when it was demolished in 1994, and Building 713 was used for flammables storage when it was demolished in 1996.

1.3.1.5 Building 714: Steam Heating Plant

The Building 714 steam heating plant and steam distribution lines were constructed in 1942 to heat the synchronizing area buildings, which included Buildings 711, 712, and 715, and also Buildings 716 and 717 to the southeast of Site 11. The steam distribution lines consisted of underground concrete conduit containing asbestos-wrapped pipes connecting Buildings 710, 711, 712, 715, 716, and 717 to the steam plant. Drawings dated February 28, 1955 and January 5, 1983 indicate steam heating lines were also connected from Building 711 to Building 719. Two 3,500-gallon diesel USTs were reportedly installed north of Building 714 in 1950 (Radian Corporation, 1995). A May 3, 1989, Base Master Plan (Tab F-3, Natural Gas System Plan) drawing indicates these two fuel oil tanks were present, in addition to "(2)-1-1/2' oil tanks." The two 3,500-gallon USTs and contaminated soil were removed in 1993 and 1994, and the Colorado Department of Labor and Employment (CDLE) Oil Inspection Section (OIS) granted closure for the USTs in a letter dated August 4, 1995 (CDLE OIS, 1995). Details of the removal are presented below in Section 1.3.2.1. Building 714 was removed in 1996. Asbestos-wrapped steam distribution pipe, encased in concrete, is still in place, as described below in Section 1.3.2.7.

1.3.1.6 Buildings 715, 716, and 717: Stoppage and Jam/Storage

Buildings 715, 716 and 717 were identified as stoppage and jam buildings in 1944 and 1945 plans, and as storage in a 1959 plan. Jammed machine guns were cleared, cleaned, and re-fired into underground tunnels along the north and south sides of the jam buildings. According to an Initial PA interview (URS, 2003), when the jam shops were closed, the tunnels were cleared out but were not caved in. Another interviewee (URS, 2003) indicated that materials such as lead shot and stands from the jam shop were buried behind the CE shops after the jam shops closed. (This referenced area of buried debris may correspond to one of the buried debris areas found under the IRP Site 3 investigation in the Leadership Development Center (LDC) area, as described in Section 1.3.2.7). These buildings were used as warehouses when they were reportedly demolished in place in the 1980s or early 1990s (An October 1981 drawing indicates these were "abandoned foundations", and these buildings were eliminated from a drawing revised January 20, 1988). The roofs had been removed a few years earlier, but items, including

large appliances, were inside the buildings, according to an interviewee who worked in CE (January 11, 2005 interview by a Buckley AFB contractor). He indicated he personally demolished Building 715, covering all demolition debris within the original building footprint. He observed that the soil abutting the north wall was sand, and junk that had accumulated in the building was removed before it was demolished.

1.3.1.7 Building 718: Compressed Air and Vehicle Operations

Building 718 was identified as a small air compressor building adjacent to the north side of Building 711 on a February 1959 drawing, and as a compressed air plant prior to removal, about 1972. The construction date is uncertain; base records list it as 1942; and February 28, 1955 and February 24, 1961 drawings show a structure in this area; however, it was not seen on reviewed aerial photographs prior to May 5, 1963.

Another Building 718 location was adjacent to Building 710, where it was used for vehicle operations from 1974 through 1994.

1.3.1.8 Building 719: Gasoline Station

Building 719, constructed in about 1949, was identified as a PW gasoline station on a February 1959 Navy plan map, and as a CE Road and Grounds shop in the Phase I Records Search (Simons, Li & Associates, 1982). Historical information and interviews indicated there may have been one to three USTs associated with this building. Versar postulated that an AST may have been present, based on the information obtained for this area. One UST, its fill port, and the former pump island area associated with Building 719 was found during the SI, as mentioned below and described in more detail in Section 1.3.2.9. No other USTs were found during test pit digging in other suspected locations in this area. Information from historic maps, reports, and interviews regarding this area is summarized below.

A December 30, 1948, NAS drawing for the PW Service Station indicates a 25- by 9-feet UST (gasoline), north and west of Building 719 and 86 feet from Building 711, was to be connected to a pump island. A February 28, 1955, NAS drawing indicates a structure in this area, and a June 25, 1980, drawing shows a "fuel filler" feature at the same location as the UST on the December 30, 1948, drawing. Copies of portions of these drawings are in Appendix B of the *Final Quality Program Plan Triad Site Inspection for Building 1011 Area of Concern, Buckley Air Force Base* (Versar, 2006). The Basewide RI Report (SAIC, 1995), states there were two 10,000-gallon USTs at Building 719 that formerly contained MO GAS, but are now empty and filled with sand. The Colorado ANG motor pool moved from Building 711 to Building 940 in about 1971; it is likely the USTs at Building 719 were abandoned at some time after this move. Two USTs of the same reported size, that were installed in the early 1940s at a motor pool in the north part of base (Building 518), were filled with sand and abandoned in the 1970s (SAIC, 1995 [Appendix J]; regulatory meeting minutes dated March 12, 1996); it is possible the tank(s) at Building 719 were abandoned at the same time. It also may be that the historical information did not accurately distinguish the number of tanks at the two sites (in the Basewide RI Report there was no diagram of the Building 719 USTs, but there were diagrams of the two Building 518 USTs and all other USTs described in the Basewide RI Report text).

However, the Buckley AFB Base Deputy Civil Engineer also thought there were two USTs in this area that were likely emptied and filled with sand (personal communication with Versar, February 2006). In addition, a base employee currently in the base mechanical shop thought there were two USTs (based on two grades of MO GAS and no diesel fuel) in the gravel and cactus landscaped area near a fill pipe that were abandoned in place (personal communication with Versar, April 2006).

During a November 17, 2005, site visit, the fuel filler feature identified on the 1980 drawing was not observed in the area that is landscaped with gravel. A nearby vertical 1-inch pipe was observed at a location that was approximately adjacent to the west corner of former Building 719. During the test pitting performed under the Triad SI in May 2006, as described in Section 1.3.2.9, the pump island area and one UST and its fill pipe were found in the general location indicated on the 1948, 1955, and 1980 drawings.

In contrast to the above information, a structure shown south of Building 719 on maps dated 1961, 1963, and 1978 (revised 1988) is identified as Building 727, and a February 1959 list of structures identifies 727 as a PW vehicle ready fuel tank. During a November 9, 2005, site visit, a concrete pad (about 12 feet by 8.5 feet) that generally corresponds to the presumed location of Building 727, was observed in this area. Three small diameter pipes (1 to 1.5 inch outer diameter) slightly protruding through the concrete pad indicated subsurface piping was present. Before the Triad SI field work was conducted, this area was thought to have been the location of a UST or AST. It is possible the piping was used to protect wires, rather than contain fuel. A base contractor interpreted potential locations for two USTs south of the Building 719 gas station, based on potential filler line imprints in the asphalt leading to the fuel island, and outline of cracked asphalt in the area surrounding the former pump island area. However, during the test pit excavation performed under the Triad SI in May 2006, as described in Section 1.3.2.9, no USTs were found in this area. Although no known historical documentation cites an AST at this location, and no evidence was observed that indicated a former structure was secured to the concrete pad, the "vehicle ready fuel tank" could have been an AST, rather than a UST. Versar reviewed several historical aerial photographs for this area; however, the scale was not sufficient to determine whether an AST was present. The *Draft Technical Memorandum of the Results of the Initial PA Records Search* (URS, 2003) reports that an April 10, 1991 map showed three USTs associated with Building 719; this map has not been located. No other information regarding the tank(s) associated with Building 719 has been found in base files or in an October 12, 2005, search of CDLE Division of Oil and Public Safety (OPS) files; therefore, it is uncertain whether there were up to two additional USTs, or potentially one additional UST and one AST, or none. Building 719 was removed in 1997.

1.3.1.9 Building 720: Heavy Equipment Repair/Storage

South of Aspen Way, Building 720, constructed in 1955 and removed in 1996, was identified as a heavy equipment repair booth on a February 1959 drawing, and the surrounding area was fenced and identified as a construction yard on an October 9, 1979, map. An interviewee confirmed the area was used for storing gravel and other bulk materials and trucks (Versar, 2007a; October 21, 2004 interview).

About 200 feet southeast of Building 720 along Aspen Way, another building (potentially a Quonset hut) is visible on 1965 through 1972 aerial photographs (Figure 1-5). No information about this potential structure has been found; however, it was also likely associated with the use of the area for heavy equipment and as a construction yard.

1.3.1.10 Building 727: Vehicle Ready Fuel Tank

Building 727 was a small structure south of Building 719 and the pump island. This structure may have been or housed a UST(s) or AST, based on a February 1959 list of structures that identifies Building 727 as a "PW vehicle ready fuel tank." As described above under Building 719, a concrete pad with three pipes that extended to the pad surface was observed in this area during a November 9, 2005, site visit, and a base contractor thought two 10,000-gallon USTs were potentially present east-northeast of this structure. However, no USTs were found in this area during the Triad SI.

1.3.2 Previous Investigations

This section presents a summary of the previous investigations and studies that have been performed at Site 11. From 1992 through 2005, environmental investigations were conducted for specific areas within or adjacent to Site 11 to address specific, limited concerns. These previous investigations and work in the area included the following:

- Investigations and tank removal for the Building 714 UST site from 1992 through closure in 1995 (Section 1.3.2.1)
- Preliminary environmental investigation for the Building 710 area (which also included Buildings 714 and 719) in 1992 (Section 1.3.2.2)
- Limited investigation of potential buried asbestos debris in March 2004 (Section 1.3.2.3)
- Sampling of free product/LNAPL, in December 2004 and April 2005, in a monitoring well found in October 2004 near Building 710 (MW710-1) (Section 1.3.2.4)
- A visual site inspection (VSI) of Building 1011 and the surrounding area in November 2004 (Section 1.3.2.5)
- A soil and groundwater sampling/firing tunnel investigation and trenching for potential buried debris in February 2005 to assess environmental impacts for the future LDC building (Sections 1.3.2.6 and 1.3.2.7)
- Sampling of the septic tank contents in the fall of 2005 and subsequent closure (Section 1.3.2.8)

On the basis of these investigations, this area was identified as an AOC, and, from the end of 2005 through 2007, the Triad SI was conducted to assess all potential remaining concerns (Section 1.3.2.9). The field investigations were conducted from March through June 2006 specifically to identify the source and extent of previously identified petroleum free product (LNAPL) and potential dissolved plume near former Building 710, delineate lead contamination associated with firing tunnels at Building 1011, and identify points of any waste release in other areas of the AOC. On the basis of the results of the Triad SI, removal actions for soil and the LNAPL were planned (Section 1.3.2.10) and implemented (Section 1.4). The remaining concern, groundwater contamination detected in two wells during the Triad SI, is addressed under this Site 11 RI.

The *Final Quality Program Plan Triad Site Inspection for Building 1011 Area of Concern, Buckley Air Force Base* (Versar, 2006) and the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b) include detailed information (e.g., sample locations, data, etc.) regarding these previous investigations; therefore, detail is included in this section and on figures only as it may be pertinent to understanding the remaining concerns and attaining the objectives of this RI. Figure 1-4 shows the soil borings and temporary monitoring well locations from the LDC investigation, and sample locations from the Triad SI, in addition to adjacent IRP Sites 2 and 3 monitoring wells. Sample locations for other investigations were generally focused on the east side of Site 11 or adjacent to Site 11. Lithology and well logs for previous investigations in the Site 11 area are included in Appendix A. The investigations and findings are summarized below.

1.3.2.1 Building 714 USTs

In 1992, a limited soil gas investigation was performed at two 3,500-gallon steel USTs containing diesel fuel for the Building 714 Steam Heating Plant (ATEC, 1992). The report (ATEC, 1992) concluded the results of the soil gas vapor probes did not appear to indicate a significant release, and noted that the steel tanks were exposed near the ground surface and appeared to be corroding.

In December 1993 and April 1994, two 3,500-gallon USTs, the contents, and surrounding soil were removed from the north side of Building 714 (A.G. Wassenaar, Inc., 1994). A total of 300 gallons of diesel fuel and sludge was removed and disposed. Soil beneath the tank and in the sidewalls was stained and contained hydrocarbon odors, which was interpreted as likely due to overfilling and/or spillage. Excavation was performed in an area 28 feet wide by 33 feet long, to a depth of 12 feet below ground surface (bgs). The highest concentrations of total recoverable petroleum hydrocarbons (TRPH) (up to 7,000 milligrams per kilogram [mg/kg]) were on the north side of the tanks. No benzene was detected in the soil samples, and toluene, ethylbenzene, and xylenes were detected at low levels, below CDLE OPS risk-based screening levels (RBSLs) (CDLE OPS, 2006). After contaminated soil was excavated, concentrations of TRPH in remaining soil ranged from nondetect to 76 mg/kg, below the current CDLE OPS standard of 500 mg/kg (CDLE OPS, 2006). CDLE OIS granted closure for the USTs in a letter dated August 4, 1995 (CDLE OIS, 1995). This letter is contained in Appendix C of the Triad SI QPP (Versar, 2006) and Appendix A of the Triad SI Report (Versar, 2007b).

1.3.2.2 Preliminary Environmental Investigation for Building 710 Area

In 1992, ATEC conducted a preliminary environmental investigation of the Building 710 area, identified as the existing vehicle defueling and maintenance facility. This investigation also included work at the adjacent Building 714 USTs (as described above) and Building 719 (asbestos survey only). At the time, the Building 710 area was used to transfer petroleum product from vehicles to aid in vehicle maintenance and repair. It was ATEC's understanding that both Buildings 710 and 719 were to be dismantled/disassembled and demolished. Prior to beginning the work, ATEC conducted a walk through investigation of the site, visually evaluated adjacent properties, and conducted historical and regulatory records review, including review of aerial photographs from 1948 through 1984 at Colorado Aerial Photo Service.

The site was described as follows (ATEC, 1992): "The existing vehicle defueling and maintenance facility consists of a Quonset hut structure and a fenced in area used for vehicle circulation. An OWS, a septic system, two 3,500-gallon steel USTs containing diesel fuel, two reportedly empty 1000 gallon steel above ground storage tanks and an underground storage tank containing oil, are located in the immediate vicinity. In addition, a leach field is located south of the Quonset hut structure." The OWS was connected to the Building 710 drains, indicated as one in the east pad and one in the west pad, and an adjacent oil storage tank (i.e., UST), in addition to the septic system leach field. "Eleven drums labelled waste oil and jet fuel were located southeast of the existing vehicle defueling and maintenance facility. Most of these drums were observed to be empty. Each drum was electrically connected to a grounding rod. No leaks or stains were observed." The ASTs were described as being in the vehicle circulation yard adjacent to Building 713, north of the fuel oil USTs. The two 3,500 gallon fuel oil USTs were associated with Building 714, as described above in Section 1.3.2.1. Building 719 was described as most recently being used for office space.

Field work was conducted from January through February 1992. Soil gas sampling was conducted to evaluate the potential impact of the OWS and adjacent UST and strategically place the soil boring/monitoring well. The report concluded these soil gas samples did not indicate a widespread contaminant plume. Soil boring B-6/monitoring well MW-6 (identified in this report as MW710-1) was described as being "installed in an assumed downgradient location and in the vicinity of the underground OWS and holding tank at the existing vehicle defueling and maintenance facility" (ATEC, 1992). The report interpreted downgradient as northwest, which differs from the current southwest interpretation. A soil sample representative of the highest photoionization detector (PID) readings (354 parts per million [ppm]), from 5 feet bgs, was submitted for laboratory analysis of volatile organic compounds (VOCs) by EPA Method 8260 and TRPH by EPA Method 418.1. VOCs detected included low concentrations of 1,1,1-trichloroethane (TCA) (0.018 J mg/kg); PCE (0.014 J mg/kg); total xylenes (1.2 mg/kg); methylene chloride (0.012 J mg/kg); and acetone (0.089 J mg/kg); and several tentatively identified compounds (TICs), including naphthalene compounds. TRPH was detected at 16,100 mg/kg.

Well installation, development, and sampling were described according to standard practices. Well MW-6 was screened from 30 to 45 feet bgs. The water level noted on the drilling rods and at completion was 35 feet; two days after completion, it was measured as

31.2 feet (the measuring points are not known). No indication of free product/LNAPL was noted. A groundwater sample was collected on February 20, 1992, and analyzed for VOCs using EPA Method 8260 and total volatile petroleum hydrocarbons (TVPH) using EPA Method 8015M. Low concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected, including 2 J micrograms per liter (µg/L) benzene, 7 µg/L toluene, 13 µg/L ethylbenzene, and 55 µg/L total xylenes, in addition to a few petroleum TICs (cyclohexane, naphthalene compounds, and undecane), and "did not exceed state ground-water quality criteria" (ATEC, 1992) (Table 1-2; well MW710-1). TVPH was detected at 9.1 milligrams per liter (mg/L). The report concluded the soil and groundwater results from B-6/MW-6 indicated a release from the OWS, and recommended further evaluation of the extent of the groundwater and soil contamination. No documentation of additional work (prior to the discovery of free product in well MW-6 [MW710-1] in October 2004 as discussed in Section 1.3.2.4) has been found.

Shallow soil sampling was performed at the drum storage area (SS-1 through SS-6) and beneath the ASTs (SS-7 and SS-8). At the drum storage area, six soil samples were collected beneath five of the drums, and screened using a PID. The samples were collected from 0 to 1 inch bgs, with the exception of SS-5, which was collected from 1 to 12 inches bgs at the same location as SS-4. The PID readings for the drum storage area samples ranged from 3.7 to 863 ppm, with the highest reading at SS-4. Based on the PID readings, a sample from SS-4 (0 to 0.5 feet bgs) was submitted for laboratory analysis of VOCs by EPA Method 8260 and TRPH by EPA Method 418.1. Benzene (0.820 mg/kg), toluene (22 mg/kg), ethylbenzene (21 mg/kg), total xylenes (120 mg/kg), chloroform (0.080 J mg/kg), and methylene chloride (0.220 J mg/kg) were detected, in addition to several petroleum TICs. As presented in the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b), these concentrations are below current CDPHE Colorado Soil Evaluation Values (CSEVs) (CDPHE, 2007) and EPA Region 9 preliminary remediation goals (PRGs) (2004b) for residential use. (In 2008, EPA Regional Screening Levels [RSLs] were developed; as described in Section 2.4, data collected under this RI are compared to the 2010 RSLs.) TRPH was detected at 9,800 mg/kg. The report concluded the surface contamination at the drum storage area appeared to be localized; however, further testing would be necessary to determine the depth and areal extent of contamination (ATEC, 1992). No documentation of additional work has been found.

The two soil samples collected beneath the two empty ASTs north of Building 714 and east of Building 713 were collected from 0 to 4 inches bgs. PID readings for these samples were 0.2 and 1.7 ppm. Because low PID readings were measured, no samples were submitted for laboratory analysis.

1.3.2.3 Asbestos Survey for Future Construction Sites

A limited investigation of potential asbestos debris was conducted east of Building 1011 (five test pits and one trench to depths up to 6.6 feet bgs) by URS in March 2004 (URS, 2004b). This investigation focused on identifying potential asbestos from demolished World War II era buildings and steam lines. Surface or near surface (1 foot bgs) debris (black concrete debris and red brick mortar fragments) was found at two locations. Fourteen samples were collected and analyzed for asbestos by Polarized Light Microscopy. No asbestos was detected.

1.3.2.4 LNAPL Discovery

On October 27, 2004, Versar, URS, and base personnel discovered and inspected a monitoring well (MW710-1) southeast of Building 1011, near former Building 710 (Figure 1-4) (Versar, 2005a). This well was subsequently determined to be well MW-6 identified in the 1992 ATEC preliminary environmental investigation as described above in Section 1.3.2.2 (the ATEC report was not found until March 2006). A bailer inside the well was raised to the surface; the bailer rope was stained black, and the bailer appeared to contain petroleum product. In December 2004, a Buckley AFB contractor indicated they measured about 10 inches of free product in the well, before the contents of the well were bailed (about 2 feet of water remained). The base collected a sample of free product on December 9, 2004, and submitted it to the Clayton Group Services for analytical testing, including gas chromatography (GC)/flame ionization detector (FID) fingerprint, infrared (IR) Scan, and specific gravity. The results showed the presence of a hydrocarbon pattern in the jet fuel range and a heavy oil, such as motor oil or hydraulic fluid. No major components were identified by IR; the substance was identified as >99% organic. The specific gravity was 0.81. No chromatograms for this analysis are available.

Subsequent analysis on the apparent two-phase free product sample for VOCs (water phase), semivolatile organic compounds (SVOCs) (solid and water phases), polychlorinated biphenyls (PCBs) (solid and water phases), metals (solid phase), and flashpoint was performed in April 2005. VOCs detected in the water phase included BTEX, 1,2,4-trimethylbenzene (TMB), 1,3,5-TMB, n-propylbenzene, and naphthalene. SVOCs detected in the water phase included 2-methylnaphthalene, naphthalene, and phenol; no PCBs were detected. The results are contained in Appendix D of the *Final Quality Program Plan Triad Site Inspection for Building 1011 Area of Concern* (Versar, 2006). Only BTEX compounds and naphthalene exceeded Colorado Basic Standards for Groundwater (CBSGs) (CDPHE, 2009a; Regulation 41). Concentrations of these chemicals were one to three orders of magnitude higher than their CBSGs.

The types of SVOCs detected in the solid phase were similar to the water phase, and included the PAHs fluorene, 2-methylnaphthalene, naphthalene, and phenanthrene. Concentrations were reported in mg/kg; therefore, they are not compared to the CBSGs. No PCBs were detected. Chromium was detected at 0.077 mg/kg, below the laboratory reporting limit (RL). The flashpoint was greater than 160°F (i.e., not ignitable).

Subsequent measurements of the free product in well MW710-1 indicated it slowly reentered the well bore after it was purged in early December 2004. As described in Section 1.3.2.9, additional work was conducted under the Triad SI to determine the extent of the LNAPL and investigate a potential dissolved phase plume. A removal action for the LNAPL has been conducted, as described in Section 1.3.2.10 and Section 1.4.

1.3.2.5 Building 1011 Visual Site Inspection

URS conducted a VSI of Building 1011 on November 19, 2004. General concerns noted included the potential for asbestos building material, patches in the back wall that led to the firing tunnels and potential for lead or other munitions in the berm behind the building, USTs

potentially still in place to the east-northeast of Building 1011 at the site of the former Building 714 boiler plant (the closure information had not yet been found), and the well with petroleum LNAPL east-southeast of Building 1011.

Specific potential environmental concerns associated with the former "Wash and Grease Racks" area included former hydraulic lift and floor vaults, based on a rectangular concrete-filled area in the floor, an elongated metal cover, and the potential for hydraulic oil in a reservoir or abandoned lines. A floor drain (e.g., sump), which tracked south to a large grate drain (e.g., sand filter) immediately outside the bay door, was identified and located on the east side of this shop. However, a June 22, 1988 mechanical demolition plan identifies a floor sump on the west side of this shop, rather than the east side (which historically was shown to have a hydraulic lift). Figure 1-4 shows the locations of a hydraulic lift and sump based on historical drawings. The sand filter was filled with sediment, and was inline with asphalt patch trending southwest to a small catch basin located about 50 feet west-northwest of Building 1012 (latrine); however, there was no apparent connection. These features are also identified on Figure 1-4. As described in Section 1.3.2.9, the hydraulic lift, sump, and sand filter were investigated during the Triad SI; and a removal action to address soil contamination associated with the sump and sand filter was planned (Section 1.3.2.10) and conducted (Section 1.4).

Three possible floor drains that may have been for sinks were observed by URS. Versar interpreted the specific locations shown east of the Wash and Grease Racks area on Figure 1-4 based on locations of sinks and water heaters in areas formerly identified as "Stores", "Buildings and Grounds", and Plumbing Shop." In 1981 and 1988 drawings, these areas were identified within the "Plumbing" shop, including Storage, Work Area, and Tool Area. No drains were observed in the area identified as a Maintenance Room during the building use as a synchronization shed; furthermore, drawings did not indicate this building was connected to the septic system during this early use of the building.

In the former "Carpenter Shop", a stored shop machine had leaked a small amount of apparent hydraulic or lube oil on the floor. No obvious cracks were observed in the floor, and the leak appeared to be recent. Some staining was observed from prior leaks.

1.3.2.6 URS LDC Activities

In February 2005, URS performed limited investigations to assess potential impacts of the firing tunnels and LNAPL to the proposed construction of the LDC. URS exposed 12 of their estimated 26 Building 1011 firing tunnels to determine possible metal impact to the soil from the operations conducted in the firing tunnels. The top of each tunnel was about 1 foot bgs, with an opening width of about 3.5 feet. Projectiles, including apparent .50-caliber armor-piercing rounds, were identified in a 5-foot long area between 12 and 17 feet from the north wall entrance to each of the firing tunnels. Steel bullet projectiles were interspersed with large and small bronze/copper jacketing material. Four soil samples were collected from two of the tunnel excavations, and lead was detected at up to 1,855 mg/kg in a sample collected from 2.4 feet bgs at one location. URS indicated this concentration was above the EPA Region 9 PRGs for residential and industrial uses of 400 and 800 mg/kg, respectively; these PRGs correspond to the CDPHE CSEVs (CDPHE, 2007). The results indicated some lead has leached from the

projectiles into the relatively permeable sand backstop material, and the area impacted by firing range activities appears to be limited in depth and width to the extent of the sand backstop fill material observed in the excavations (URS, 2005b). As described in Section 1.3.2.9, the firing tunnels were investigated during the Triad SI; and a removal action was planned (Section 1.3.2.10) and implemented (Section 1.4) to address the contamination.

URS drilled seven borings to depths of 25 to 30 feet bgs to investigate potential soil or groundwater contamination, and completed six of these borings as temporary wells (LDC-B1 through LDC-B6) (Figure 1-4). Core samples were taken at 5-foot intervals, beginning at 10 feet bgs, and screened with a PID for organic vapors. Bedrock was reached about 12 to 20 feet bgs, and groundwater was first observed at about 20 to 25 feet bgs. Two soil samples from one boring (LDC-B1), which was near the location of former Building 710 and 75 feet northwest of the well containing LNAPL, had elevated PID screening levels at 15 and 20 feet bgs (56 and 23 ppm, respectively). The sample with the highest PID level was analyzed for total petroleum hydrocarbons (TPH) using a field screening method; 46 ppm TPH was detected, well below the CDLE OPS standard of 500 mg/kg. Six of the seven borings were completed as temporary piezometers/wells, with either 1- or 2-inch diameter polyvinyl chloride (PVC) casing, and a 5-foot screen. No water was present in the boring (LDC-B7) downgradient of the well that contained LNAPL (MW710-1); therefore, this boring was not completed as a temporary well. It is assumed perched groundwater was present in the other wells and not in this well, and this boring (to 25 feet bgs) was not deep enough to encounter the water table, as indicated by water levels in the wells south of former Building 710. Groundwater was interpreted as flowing from northeast to southwest (URS, 2005b). (As described below in Section 1.3.2.10, these temporary wells were subsequently abandoned.)

URS also trenched in three locations in the area of former Building 710 in an attempt to locate an OWS or other potential source areas; no evidence of this or other potential sources was observed. The trenches were dug to a depth of 3 to 4 feet bgs over a cumulative distance of about 73 feet. No petroleum odor or staining was observed. A 1-foot-thick zone containing potential coal and clinker fragments was observed in the trench to the east of former Building 710. Surficial coal, asphalt, and concrete fragments and a subsurface 4-inch diameter cast iron pipe, likely an abandoned sewer pipe, were identified southwest of former Building 710. A suspected former soil boring filled with bentonite or grout was observed at the east end of the former Building 710 footprint.

One groundwater sample was collected from a temporary well installed at boring LDC-B5 (an upgradient well closest to the proposed LDC location) and analyzed for VOCs by EPA Method SW8260B. No VOCs were detected above laboratory RLs (Table 1-2); however, chloromethane was detected at a trace level of 0.3 µg/L. There is no CBSG for this chemical.

1.3.2.7 Versar LDC Activities

In February 2005, Versar expanded IRP Site 3 Landfill investigation efforts to delineate the extent of buried waste and debris east of the center of Building 1011, north of Aspen Way and west of Aspen Street, in support of the LDC siting (Figure 1-3) (Versar, 2005b). Geophysical surveys using an electromagnetic (EM) 31 ground conductivity system and an

EM61 metal detection survey were conducted over about 8 acres to identify potential anomalies caused by buried landfill debris. Six EM31 anomalies and ten EM61 anomalies, including six that corresponded to the EM31 anomalies, were identified. Trenching/test pitting at the anomalies was then conducted to verify whether buried debris was present.

The two most prominent anomalies, identified by both EM31 and EM61, corresponded to the locations of former Buildings 715 and 716. The presence of building debris (e.g., concrete walls, blocks, and debris; glass; and piping), fill (including sand), and steam lines (wrapped in asbestos and encased in a concrete conduit) connecting the buildings were confirmed by trenching. No evidence of bullet fragments was observed. Other EM31 anomalies did not correspond to subsurface debris, with the exception of in-place asphalt at one location and apparent recent trash (glass, wood, and plastic) at another location.

The largest EM61 anomaly corresponded to buried debris north of former Buildings 715 and 716 confirmed by trenching (e.g., metal, wood, and a railroad rail) and also by observations of large debris (e.g., automobile parts, concrete, and asbestos-containing material [ACM]) during utility installation along Aspen Street. A former CE employee (January 11, 2005 interview by a Buckley AFB contractor) indicated debris was probably buried in this area upon the demolition of Buildings 716 and 717, which were used for junk storage prior to demolition. Northwest of this area near former Building 712, the geophysical survey could not be conducted because construction trailers were parked over the area; another area of buried debris was found by trenching. URS dug two test pits in this area to help delineate the extent of debris.

An EM61 anomaly north of the center of Building 1011, about 30 feet northeast of the building, corresponded to the location of a UST. This UST is apparently the gasoline UST associated with the building use as a synchronization shed. A 2-inch plastic water line on top of the UST was broken when the UST was uncovered, releasing water in the test excavation. A subsurface wood wall bordered the south side of the UST, and wood debris, likely remnants of the cover for the pump and piping, was in the hole. No odors were noted, and no PID readings were measured. The tank was rusty, crushed, and appeared to be empty. As described in Section 1.3.2.9, a boring was drilled to investigate this UST during the Triad SI, and no contamination was indicated.

Another EM61 anomaly corresponded to the location of former Building 710. As described above, URS conducted test excavations in this area in an attempt to locate an OWS or other potential sources; but none were found.

1.3.2.8 Septic Tank Closure

In September 2005, as part of the Building 1011 demolition, Buckley AFB Engineering hired a septic system contractor to empty the contents of the septic tank southeast of former Buildings 1011 and 710 (which was shown on base maps to be connected only to the latrine - Building 709/1012). The contractor pumped out the first load (about 2,500 gallons of liquid) and disposed of the contents at McDonald's Farms Enterprises (a land farm operation). Because the remaining contents were apparently more characteristic of sand trap/OWS waste than typical septic tank waste (e.g., based on odor and appearance), the contractor disposed of the second

load (about 2,500 gallons of liquid and sludge) at Airvac Services treatment plant. About one-half of the contents remained in the septic tank.

Before disposing of the remaining waste, Buckley AFB Environmental analyzed a sample of the contents for VOCs. The results indicated the remaining septic tank contents had likely been impacted by painting and potentially other operations in the CE shops. Compounds detected in the sample included acetone, BTEX, 2-butanone (MEK), and chlorobenzene. Xylenes, chlorobenzene, and MEK were detected at the highest concentrations (from 110 to 360 µg/L). Xylene is used as a thinner for paint and in paints and varnishes, chlorobenzene is a common paint thinner ingredient, benzene is also used as a paint thinner, and MEK is a common paint remover. The flashpoint was >200°F (i.e., not ignitable). The CBSGs do not apply to the septic tank contents; however, for purposes of assessing potential releases to groundwater from piping or the leach field, the following comparison was made. Of the analytes detected, only benzene and chlorobenzene exceeded CBSGs. Benzene was detected at a concentration of 16 µg/L, compared to the CBSG of 5 µg/L, and chlorobenzene was detected at 170 µg/L, compared to the CBSG of 100 µg/L.

To assess whether the remaining contents met Metro Wastewater Reclamation (Metro) discharge limits, Buckley AFB collected a sample of the remaining sludge and liquid on October 27, 2005, and analyzed for it for TVPH, total extractable petroleum hydrocarbons (TEPH), and eight total metals. TVPH was detected at 2.5 mg/L, and TEPH was detected at 230 mg/L. All eight metals were detected, at concentrations ranging from 0.019 mg/L (silver) to 21 mg/L (zinc). Because the Metro limits were not met for all the constituents, when the remaining septic tank contents (about 5,400 gallons) were pumped out on December 8, 2005, the contents were disposed as nonhazardous waste at the Browning-Ferris Industries (BFI) landfill.

On December 16, 2005, the concrete slab forming the top of the tank, which had two access points about 30 feet apart, was removed to facilitate filling the tank for closure. The tank was about 30 feet (north-south) by 15 feet (east-west) and 6 to 8 feet deep, and divided into two primary chambers, with a baffled area between. Both the north and south chambers had 8-inch diameter pipes entry/exit pipes at the top of the tank. Although a pumper truck had been previously used to remove as much of the contents as possible, some water and about 6 inches of black sludge remained in the bottom. The sludge was sampled and analyzed for toxicity characteristic leaching procedure (TCLP) VOCs, SVOCs, pesticides, PCBs, and metals to determine whether it could be left in place. The analyses indicated the material was nonhazardous. 1,4-dichlorobenzene was detected, at a concentration below the TCLP regulatory limit. Trace levels of TMB, benzoic acid, and naphthalene were also reported. Based on these results, the limited amount of remaining sludge was left in place, the pipes entering the tank were cemented closed, the tank was filled with soil to about 1 foot bgs, the soil was then covered with plastic to limit infiltration, and about 1 foot of topsoil was placed over the surface.

The manifests and septic tank data described above are contained in Appendix A of the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b).

1.3.2.9 Triad SI for Building 1011 AOC

Field investigations under the Triad SI for the Building 1011 AOC were conducted in March through June 2006 to characterize this AOC, and specifically, identify the source and extent of previously identified free product (petroleum LNAPL) and potential associated dissolved plume near former Building 710, delineate lead contamination associated with firing tunnels at Building 1011, and identify points of any waste release in other areas of the AOC. The AOC was divided into three primary types of sources and releases to be investigated: (1) refueling truck maintenance - LNAPL and dissolved-phase plume, (2) synchronization and stoppage and jam - munitions-related constituents, and (3) other potential sources/releases that had not yet been investigated. The results of the investigations are described below for each of these sources/releases. Table 1-2 summarizes the detected VOCs in groundwater. Other data tables are contained in the *Final Triad Site Inspection Report, Building 1011 Area of Concern* (Versar, 2007b).

LNAPL Investigation

Headspace vapor and groundwater sampling of previously installed wells, soil gas and drilling demonstrations of method applicability (DMA) and follow-on soil gas survey, temporary and permanent monitoring well installation and sampling, and test pit digging were conducted to meet the objectives of the LNAPL investigation. The Triad SI indicated the apparent sources of petroleum free product, an OWS and associated oil UST, are no longer present. Soil and groundwater data indicated the LNAPL was limited in extent, it is not a source of dissolved phase groundwater contamination above CBSGs (Regulation 41), there is no significant soil contamination that is a source of groundwater contamination, the contamination does not pose an unacceptable level of risk to human health or the environment, and the LNAPL is not significantly recoverable. During the Triad SI, the LNAPL was only present in one well and not in the five wells that were 10 to 15 feet away. The LNAPL was on groundwater that is about 28 to 30 feet bgs; the water-bearing zone is a dark gray claystone which appears to have limited the mobility and migration of the LNAPL. Although the former drum storage area was not specifically investigated during the Triad SI, the Triad SI report concluded previous sampling in 1992 indicates it does not likely represent a significant remaining source of contamination (i.e., although TRPH was detected at 9,800 mg/kg, no petroleum hydrocarbon constituents were detected above screening levels). In addition, groundwater sample data collected under the Site 11 RI confirm potential releases from the former drum storage area have not impacted groundwater downgradient of this area.

The Triad SI Report recommended that removal of this petroleum LNAPL from well MW710-1 be conducted and the adjacent monitoring wells should be periodically checked to verify that the LNAPL is not migrating into these wells. In addition, the six temporary wells installed by URS (LDC-B1 through LDC-B6) that monitor perched groundwater were recommended for abandonment. As described in Sections 1.3.2.10 and 1.4, the Air Force has implemented these recommendations.

Firing Tunnel Investigation

Test pit digging and soil sampling at 13 of the former firing tunnels at Building 1011 was conducted during the Triad SI to delineate and assess the soil contamination. Bullets and lead contamination in soil were delineated, primarily at the ends of these former firing tunnels between about 10 to 16 feet from the former back (north) wall of Building 1011. Lead was the risk-driving chemical of concern (COC), although elevated levels of antimony, copper, and iron were also found. Lead concentrations ranged up to 17,500 mg/kg, with an average concentration of 636 mg/kg. Lead above the residential risk-based level of 400 mg/kg was present at 7 of the 10 former Building 1011 firing tunnels that were sampled, in soil from about 1 to 3 feet bgs. All except one of the lead concentrations above 400 mg/kg also exceeded industrial/worker risk-based level of 800 mg/kg. Antimony, copper, and iron were detected above industrial/worker but not residential risk-based levels. TCLP lead data indicated the soil would likely be considered hazardous upon excavation. Deeper soil and groundwater data indicated that the soil-to-groundwater impact from lead and other associated metals was negligible. The presence of bullets/bullet fragments could typically be used to predict the locations of elevated lead concentrations, and the location and extent of impacted soil appeared to be generally predictable, with elevated lead concentrations and bullets/bullet fragments in soil at the ends of the former firing tunnels.

The Triad SI Report recommended that removal of the impacted soil should be evaluated. As described in Sections 1.3.2.10 and 1.4, the Air Force implemented this recommendation and conducted a removal action for the firing tunnel soil.

Investigation of Other Potential Sources

Other potential sources of contamination in the Building 1011 AOC that had not previously been investigated included those associated with the Building 1011 motor pool activities and CE shops, such as hydraulic lifts, drains (including potential sump and sand filter) and potential associated septic system, paint booths, associated waste materials potentially stored or spilled on site, and USTs, including gasoline USTs associated with Building 711 (1011) and Buildings 719/727. Soil boring sampling, sediment sampling, test pit digging, and monitoring well installation and sampling were conducted to investigate these other potential sources.

These investigations indicated contamination was present above the regulatory comparison levels at two of the three sediment sample locations (sump and sand filter) and two of the eight monitoring well locations (1011MW06 and 1011MW07). In addition, one UST and pump island at Building 719 were found, and, although stained soil with an odor was observed in soil in the test pits at and near the pump island and in the well boring adjacent to the UST, petroleum hydrocarbon constituents were not detected at levels of concern in the soil or groundwater. No contamination was found at the UST adjacent to the north side of Building 1011. Figure 1-6 shows the detections of VOCs with groundwater standards for sampling conducted for the Investigation of Other Potential Sources under the Triad SI. Table 1-2 summarizes the VOC data for the monitoring wells.

The sump and sand filter were small subsurface structures (e.g., 3-feet wide, 3-feet deep, and about 3- to 6-feet long) about 25 feet apart that were constructed of cement or concrete blocks, and potentially connected through a drain line. The sump was inside the building, while the sand filter was outside Building 1011. Before the Triad field work was conducted, it was thought that the sand filter drained to the catch basin to the southwest, based on a linear depression in the asphalt. However, the grate to the catch basin was removed, and there was no evidence of a current or former inlet pipe. The contents of these structures were sampled and found to contain contaminated sediment. The COCs in the sump sediment were PCE and TCE. PCE (3.52 J mg/kg) was detected above EPA Region 9 PRGs and CDPHE CSEVs for residential and worker exposure and groundwater protection, and TCE (0.227 mg/kg) was detected above the CDPHE residential CSEV. The COCs in the sand filter sediment were six PAHs, with benzo(a)pyrene (12.1 mg/kg) exceeding the EPA Region 9 PRGs and CDPHE CSEVs (residential and worker) by the highest amount. Although high levels of TEPH were detected in the samples (3,580 mg/kg in the sand filter, and 12,300 mg/kg in the sump), the only petroleum constituents detected above residential risk-based levels were PAHs in the sand filter. The extent of the sampled material appeared to be contained within the walls and floors, which appeared intact. However, although no soil contamination was observed in nearby borings (6 to 30 feet away), the Triad SI concluded the potential existed for underlying soil to be impacted and this area to be a source of PCE contamination detected in groundwater at downgradient well 1011MW06.

In the groundwater from well 1011MW06, PCE was detected above the CBSG, at a concentration of 40.8 µg/L, compared to the CBSG of 5 µg/L. Low concentrations of TCE (1.96 µg/L) and cis-1,2-dichloroethene (DCE) (0.636 F µg/L), in addition to primarily petroleum-related compounds, were detected below the CBSGs. The contamination occurred in groundwater about 22 to 23 feet bgs, within a permeable medium- to coarse-grained, loose sand that likely influences contaminant migration. PCE was commonly used for metal degreasing. TCE and cis-1,2-DCE, which were detected at low concentrations, were used as solvents and both are also degradation products of PCE. It was uncertain whether the Wash and Grease Racks area was associated with release of PCE that was detected in this downgradient well. The extent of the groundwater contamination identified in this well was not defined under the Triad SI.

In the groundwater from well 1011MW07, chlorinated solvents, including TCE (7.81 µg/L), carbon tetrachloride (7.10 µg/L), and chloroform (25.8 µg/L), were detected above the CBSGs; and 1,2-dichloroethane (DCA) (1.50 µg/L) was detected above the lower risk-based CBSG, but below the higher CBSG which is the drinking water standard/maximum contaminant level (MCL). The contamination occurred in groundwater that was about 25 feet bgs. The source of the VOCs was likely chemicals associated with vehicle repair in Building 1011; however, the release mechanism was uncertain. Although the closest downgradient well did not contain elevated levels of these compounds, the extent of the groundwater contamination found in this well was not defined under the Triad SI.

Based on the Investigation of Other Potential Sources, the Triad SI Report recommended the following:

- No further investigation of, or action for, the 10,000-gallon gasoline UST in the landscaped area northwest of former Building 719 or the 1,000-gallon gasoline UST north of Building 1011, because there appears to be no regulatory driver to remove these USTs. If additional UST(s) remain at the Building 719/727 area, the existing data indicate they have not resulted in a significant release to the environment.

- No further investigation or action for the hydraulic lift at Building 1011. It is possible that hydraulic lift components (e.g., piping, vessels) remain in the investigated area or other areas of the building.

- Removal of the sump and sand filter and their contents, and potentially underlying soil. Although the structures appeared to be intact, and no soil contamination was observed in the well boring to the south (6 feet from the sand filter) or in the boring to the east (30 feet from the sump), underlying soil could be impacted. In addition, drainage from these features through piping or other means could have contributed to the groundwater contamination in well 1011MW06. The disposition of the liquid and solid wastes during active use of these structures is not known (e.g., transferred to a holding tank or drum, taken off-site, etc.). The recommended removal and well 1011MW06 groundwater investigation would help address these uncertainties, including determining whether this area is the source of PCE contamination detected in the groundwater. Implementation of this recommendation has been completed.

- Additional investigation to identify the source of the chlorinated solvent (TCE, chloroform, carbon tetrachloride, and 1,2-DCA) groundwater contamination in well 1011MW07, the source of the PCE groundwater contamination in well 1011MW06, and the extents of contamination, with the priority to determine whether groundwater contamination is migrating off base. As or after the sources of contamination are identified and the extent of contamination is delineated, hydrogeologic and physiochemical data should be collected to support potential remediation options. CDPHE considered this investigation a high priority, as documented in a December 28, 2007 letter (Versar and Prudent, 2009a). This recommendation to identify the sources and extent of groundwater contamination, is addressed by this RI.

1.3.2.10 Engineering Evaluation/Cost Analysis

An Engineering Evaluation/Cost Analysis (EE/CA) which evaluates removal action (cleanup) alternatives for contaminated soil at the Building 1011 firing tunnels and sump and sand filter, and identifies recommended removal action alternatives, was finalized in April 2008 (Versar, 2008a). The EE/CA also documents the additional evaluation of and removal of petroleum LNAPL found in a limited area (one well), and abandonment of the temporary wells

in the LNAPL area. The recommended removal action to address the sump and sand filter was excavation and off-base disposal, including sampling of surrounding soil. For the firing tunnels, the recommended removal action to address soil containing lead concentrations above 400 mg/kg and soil with bullets/bullet fragments with lead was excavation, on-site stabilization, and off-base disposal. As described in Section 1.4, the firing tunnels and sump and sand filter removal actions have been implemented.

Before removal of the LNAPL, monitoring of the LNAPL in well MW710-1 and the five surrounding wells installed during the Triad SI was conducted from September through December 2007. The observations confirmed the LNAPL was stable and limited to one well in an area less than 25 feet long. In December 2007, residual LNAPL (about 2 gallons) was removed from well MW710-1, followed by placement of a sorbent sock in the well, and continued monitoring of the site. In addition, temporary wells LDC-B1, LDC-B2, LDC-B4, LDC-B5, and SG21W (a temporary well installed to monitor the LNAPL) were abandoned in accordance with Rule 16 of the Colorado Water Well Construction Rules in December 2007 through January 2008. Temporary wells LDC-B3 and LDC-B6 were not found. The LNAPL area work through February 2008 was reported in the *Final Engineering Evaluation/Cost Analysis for Site 11 Soil and Petroleum LNAPL* (Versar, 2008a). Subsequent work is summarized in Section 1.4, and presented in Appendix B.

1.3.3 Summary of Previous Investigations

As described above, previous investigations of the Site 11 (Building 1011) area, from 1992 through 2007, included analyses for VOCs, SVOCs, PAHs, PCBs, TVPH, TEPH, metals, and asbestos. Media analyzed included soil vapor, soil, sediment, groundwater, and liquid and solid contents of vessels. Not all analyses were performed on all samples; the analyses were typically selected based on site knowledge. These investigations identified site-related contaminants (detected above regulatory standards or screening levels) to include the following:

- Petroleum hydrocarbons, including BTEX compounds and naphthalene in free product, and TEPH and TVPH in soil at the Building 710 LNAPL area (free product addressed by LNAPL removal action)

- TRPH in surface soil at the Building 710 drum storage area in 1992 (specific petroleum constituents did not exceed screening levels)

- TRPH in soil at the Building 714 USTs, which was removed with the USTs in 1994

- Benzene and chlorobenzene in the septic tank contents (also acetone, toluene, ethylbenzene, xylenes, and MEK at low levels) which may have been from paint thinners, paints, varnishes, and paint remover (contents pumped out and disposed in 2005)

- Ammunition-related metals (lead, antimony, copper, and iron) in soil at the former Building 1011 firing tunnels (addressed by 2009 removal action)

- PAHs and TEPH in sediment in the Building 1011 sand filter (addressed by 2009 removal action)

- TCE, PCE, and TEPH in sediment in the Building 1011 sump (addressed by 2009 removal action)

- PCE in groundwater at well 1011MW06

- TCE, 1,2-DCA, chloroform, and carbon tetrachloride in groundwater at well 1011MW07

In addition, asbestos-wrapped steam lines are present in the subsurface, but these have been observed to be encased in concrete conduits at the east end of the site; therefore, the asbestos is not expected to be released to the environment unless it is disturbed. As described in Section 1.3.2.3, no asbestos was detected in soil samples collected to investigate potential asbestos from demolished World War II era buildings and steam lines.

This RI addresses the chlorinated solvent contamination in groundwater, detected in wells 1011MW06 and 1011MW07.

1.4 REMEDIAL ACTION

Remedial/removal actions have been conducted for soil at the Site 11 (Building 1011) former firing tunnels and sump and sand filter. In addition, petroleum LNAPL was removed from a monitoring well at the former Building 710 area. The soil removal actions are documented in the *Final Completion Report for Site 11 (Building 1011 Area) Soil Removal Action (Versar, 2010).* The final report of the LNAPL removal and monitoring is contained in Appendix B of this report.

The soil removal action at the firing tunnels was performed in September through October 2009 to address lead and bullet-contaminated soil. Approximately 105 cubic yards of soil were excavated and treated with lead stabilization reagent to render the soil nonhazardous, and then disposed of at an off-base Resource Conservation and Recovery Act (RCRA)-permitted Subtitle D landfill, Allied Waste/Republic Services Tower Road Landfill. After excavation, confirmation sampling and analysis of unexcavated soil remaining in each of the removal areas was performed.

The removal action for the sump and sand filter was conducted in October through December 2009, and included removal of these structures and surrounding soil, and sealing of remaining piping. Initial sampling and analysis of soil adjacent to and underlying the structures indicated that PAHs, but not PCE or TCE, were present above cleanup levels; so additional excavation was required. These data indicated this area was not a source of PCE groundwater contamination in former well 1011MW06. A total of about 26 cubic yards of soil and other materials (concrete, rebar, asphalt, metal, plywood, and piping) was excavated and disposed of at an off-base RCRA-permitted Subtitle D landfill, Denver Arapahoe Disposal Site (DADS).

To minimize potential future issues, in December 2007, the LNAPL was removed (pumped) from well MW710-1, and a monitoring and removal program has been implemented, as described in the *Final Engineering Evaluation/Cost Analysis for Site 11 Soil and Petroleum LNAPL* (Versar, 2008a). Passive recovery has continued through the use of a sorbent sock in the well; however, only a minor amount of LNAPL has reentered the well. No LNAPL was observed in four other surrounding wells through July 2008; however, in November 2008, a thin apparent thickness (0.02 foot) of LNAPL was measured in the upgradient well, which is about 10 feet away, and a sorbent sock was placed in this well. An updated monitoring report, through February 2009, was submitted to the regulatory agencies in April 2009. A final report of the removal and monitoring, which includes data collected through June 2010, is included in Appendix B of this RI report. This report requests discontinuance of the LNAPL monitoring and removal program, based on the minimal recovery of LNAPL, even with water-level fluctuations of about 2.5 feet since the LNAPL was removed.

No remedial or removal actions have been conducted to address the chlorinated solvent groundwater contamination delineated under this RI.

1.5 REPORT ORGANIZATION

In addition to the Executive Summary, this report is organized into seven sections as follows:

- Executive Summary
- Section 1.0, Introduction
- Section 2.0, Investigation Procedures
- Section 3.0, Investigation Results
- Section 4.0, Contaminant Fate and Transport
- Section 5.0, Baseline Risk Assessment
- Section 6.0, Conclusions and Recommendations
- Section 7.0, References

The following appendices are included to provide additional information regarding the site:

Appendix A: Lithology Logs from Previous Investigations

Appendix B: Report of LNAPL Removal and Monitoring Through June 2010

Appendix C: RI Field Forms (including Lithology Logs, Well Construction, Well Development, and Well Sampling)

Appendix D: Photographs

Appendix E: Survey and Groundwater-Level Data

Appendix F: Investigation-Derived Waste (IDW) Disposal Documentation

Appendix G: Data Quality Assessment and Analytical Data

Appendix H: Well Inventory

Appendix I: Risk Evaluation

2.0 INVESTIGATION PROCEDURES

The investigation presented in this report consisted of drilling monitoring wells; collecting groundwater, sediment, and surface water samples for fixed-base and mobile laboratory analysis; measuring water levels; surveying; and evaluating the results. These tasks were conducted under the Triad approach, incorporating real-time measurement technologies and dynamic work strategies (DWS). Section 2.1 presents the project objectives, Section 2.2 summarizes the field procedures for each type of task, Section 2.3 describes the laboratory analysis, and Section 2.4 presents the methodology for evaluation of data collected during the investigation.

Under the Triad approach, a DWS was implemented, which includes a flexible and adaptable approach to sampling and data collection that can continually be adjusted and refined in the field as new data are generated and data gaps are identified. General sampling approaches and initial sampling locations were identified in the Final Site 11 RI QPP (Versar and Prudent, 2009a), but the details of the data collection approach were developed and adapted in the field, in accordance with EPA guidance (EPA, 2005). As and after each phase of data was collected, the conceptual site model (CSM) was refined and additional investigation tasks were developed with the Buckley AFB Technical Working Group (TWG), as documented in two addenda to the Final Site 11 RI QPP (Versar and Prudent, 2009b, 2009c).

2.1 PROJECT OBJECTIVES

Previous investigations under the Triad SI for the Building 1011 AOC (Versar, 2007b) had identified chlorinated solvents above Colorado groundwater standards in two monitoring wells in separate areas of the site. The objectives of the investigation described in this RI report were to characterize the nature and extent of this contamination and potential associated risks. The primary objective was to identify the source, range, and extent of contaminant concentrations in groundwater, with the priority to determine whether elevated concentrations are present in groundwater at the Buckley AFB boundary. As determined during the RI field program, because elevated concentrations were present in groundwater at the Buckley AFB boundary, the field investigation was expanded to include collection of off-base hydrological and analytical groundwater, surface water, and sediment data. The specific objectives of the RI for Site 11 groundwater, as stated in the Final Site 11 RI QPP, were to:

- Delineate the extent of the groundwater contamination identified in wells 1011MW06 and 1011MW07, focusing on downgradient areas near the Buckley AFB boundary

- Identify, as possible, the sources of chlorinated solvent contamination in wells 1011MW06 and 1011MW07

- Collect site-specific data to provide hydrogeological information to interpret the groundwater flow and contaminant migration system.

These objectives were met by installing and monitoring wells upgradient, downgradient, and crossgradient of wells 1011MW06 and 1011MW07; and using direct-push techniques, groundwater grab sampling, and on-site analysis to further define the extent of contamination and preferential pathways for contaminant migration. In addition, because the contamination appeared to extend toward East Toll Gate Creek, surface water and sediment sampling was conducted. No soil sampling, other than soil sampling analysis for IDW characterization, was conducted as described in the Final Site 11 RI QPP, because no indication of contamination was observed in the soil during drilling of the monitoring wells. The Final Site 11 RI QPP (Versar and Prudent, 2009a) described potential work as including aquifer testing; however, this task was not conducted because the additional aquifer information needed will be better defined under the next step of a Feasibility Study (FS).

2.2 INVESTIGATION ACTIVITIES

The Site 11 RI field work was performed from March 2009 through September 2010. Types and quantities of investigative data obtained included the following:

- Installing 16 additional monitoring wells (although two were installed under a USACE contract); 1 of the wells is considered temporary
- Collecting and analyzing a total of 40 investigative groundwater samples from the new and previously installed wells for VOCs, with two samples also analyzed for 1,4-dioxane
- Collecting and analyzing 3 sediment and 3 surface water samples for VOCs
- Collecting or attempting to collect grab groundwater samples from 82 direct-push holes, including 32 on-base and 50 off-base locations
- Analyzing 80 investigative grab groundwater (including 1 collected during drilling of a monitoring well and 1 from a well without purging), 3 surface water, and 3 sediment samples, using an on-site mobile laboratory for a select suite of VOCs
- Measuring water levels in all site and other nearby wells (up to 37 wells) during 4 measurement rounds.

The approach for the investigation is described in the *Final Quality Program Plan, Site 11 (Building 1011 Area) Remedial Investigation* (Versar and Prudent, 2009a), which contains the Work Plan and Field Sampling Plan (FSP), a section of which is the Sampling and Analysis Plan (SAP) Addendum. After the initial phase of investigation was completed, the investigation approach was refined, as documented in the *Final Addendum to the March 2009 Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar and Prudent, 2009b). Because chlorinated solvents were detected in groundwater at the Buckley AFB boundary, additional refinements were made for the third phase of investigation, as documented in the *Final Second Addendum to the March 2009 Final Quality Program Plan for*

Site 11 (Building 1011 Area) Remedial Investigation (Versar and Prudent, 2009c). Section 2.2.1 summarizes the investigation program and procedures that were implemented; Section 2.2.2 presents the chronology of the field work, and Section 2.2.3 presents the field quality control (QC) measures. The field forms from the investigation are included in Appendix C. Select photographs from the investigation are included in Appendix D. Notable deviations from the planned approach are noted below.

2.2.1 Investigation Program

The RI for Site 11 groundwater consisted of completing the following tasks, which are described in detail in the following listed subsections:

- Mobilization activities (Section 2.2.1.1)
- Three phases of monitoring well installation, development, and groundwater sampling (portions of the last phase was conducted under a USACE-funded contract) (Section 2.2.1.2)
- Three phases of direct-push groundwater sampling and on-site analysis by a mobile laboratory (Sections 2.2.1.3 through 2.2.1.5)
- Surface water and sediment sampling (Section 2.2.1.6)
- Water-level measurements to establish groundwater flow direction (Section 2.2.1.7)
- Surveying the field data collection sites (Section 2.2.1.8)
- Disposing of the IDW (Section 2.2.1.9)

The procedures for these activities are described in the following sections.

2.2.1.1 Mobilization Tasks/Site Access

Prior to commencing field activities, Versar submitted Entry Authorization Letter (EAL) for Unescorted Access to Buckley AFB for Versar and subcontractor personnel to the Buckley AFB Environmental Flight, and, when needed, vehicle and individual permits for personnel to access the base were obtained from Buckley AFB security. Before conducting the first and second phases of on-base drilling and well installation, Versar submitted an Air Force (AF) Form 103 (Base Civil Engineering Work Clearance Request). This form is needed for Buckley AFB personnel to locate and mark underground utilities prior to invasive activities, in addition to obtaining approvals from other base organizations. The two on-base wells installed during the third phase of investigation were installed under a USACE-funded contract and associated site utility clearance, to replace wells abandoned by the USACE during expansion of Aspen Way (1011MW05 and 1011MW06).

For the off-base investigation, conducted under the third phase of investigation, Buckley AFB requested access from the City of Aurora to conduct the work on their property. Versar contacted other adjacent property owners for permission to cross their property. The management company for Foxdale Condominiums, south of the site, agreed to allow access. Access to the City of Aurora property was granted under an agreement between the City and Versar, executed on September 11, 2009, and renewed on February 10, 2010. With execution of this agreement, Versar was required to submit an access plan to the City of Aurora Parks and Open Space Department. Versar, City of Aurora, and Air Force personnel met at the site on September 30, 2009 to review the work and plan for access. The access plan was submitted on October 21, 2009, and approved on October 30, 2009. Versar submitted a revised access plan map to the Aurora Parks and Open Space Department on March 18, 2010, when it was determined travel from Airport Boulevard would be needed to access the area north of East Toll Gate Creek. Aurora requested, and was given assurances that if the existing vegetation was disturbed during the investigation, the Air Force committed to restoring these areas based on conditions at the time of the investigation, in accordance with applicable portions of the Aurora Native Grass Seeding and Restoration Guidance Manual dated September 10, 2009.

Versar obtained utility clearance for the off-base investigation area from Utility Notification Center of Colorado (UNCC), which included meeting Aurora Water personnel at the site to review the location of a sewer line prior to each planned mobilization, on November 17, 2009; February 11, 2010; April 14, 2010, and May 24, 2010. Versar submitted a Notice of Intent to Construct Monitoring Hole(s) form to the Colorado Division of Water Resources on November 19, 2009. No notice of installation was submitted, based on subsequent communication with Site 10 personnel, who indicated these submittals are not currently done for either on- or off-base hole/well installations for Buckley AFB.

2.2.1.2 Monitoring Well Installation, Development, and Sampling

This section describes the drilling and monitoring well installation, development, and sampling procedures for 16 wells that were installed under the RI to determine and monitor the extent of chlorinated solvent groundwater contamination previously detected in wells 1011MW06 and 1011MW07 at Site 11. Figure 2-1 shows all well locations. Well construction information is summarized in Table 2-1, Table 2-2 summarizes the sample analyses for all media, and Table 2-3 summarizes the monitoring well sampling and water-level measurements.

Monitoring Well Drilling and Installation

Initial RI groundwater monitoring wells (11MW01 through 11MW08) were installed at eight locations from March 10 to 17, 2009. These well locations included one upgradient of well 1011MW07 (11MW04); four to assess the extent of PCE in well 1011MW06, including one upgradient (11MW05), two crossgradient (11MW06 and 11MW07), and one downgradient (11MW08); in addition to three wells along the Buckley AFB boundary (11MW01 through 11MW03) (Figure 2-1). The well location upgradient from well 1011MW06 was moved about 100 feet southeast of the location proposed in the Final Site 11 RI QPP, based on interpretation of the groundwater flow direction and applying the Triad approach during the drilling program.

Under the second phase of the RI, from June 29 to July 1, 2009, five wells (11MW09 through 11MW13) were drilled and installed to monitor the PCE plume. These locations included three (11MW09, 11MW10, and 11MW11) near the source of the plume (near well 11MW05); one (11MW12) within the plume at the Buckley AFB boundary; and one (11MW13) within the plume about 200 feet upgradient of the base boundary, and about 200 feet downgradient of former well 1011MW06. The results of the June 2009 groundwater grab sampling and analysis, described in Section 2.2.1.3, were used to select these two locations (11MW12 and 11MW13) that monitor and define the PCE plume downgradient of former well 1011MW06.

Under the third phase of the RI, three monitoring wells were drilled and installed in May and June 2010. This phase included installation of one temporary off-base well (11MW14) and two on-base wells (11MW15 and 11MW16). The two on-base wells were installed by Versar under a USACE-funded contract (to replace wells 1011MW05 and 1011MW06 in the RI program that USACE abandoned because of the expansion of Aspen Way). These wells are adjacent to Aspen Way; one about 40 feet downgradient of former well 1011MW06, and one about 35 feet downgradient of well 1011MW07. Off-base well 11MW14 was installed north of East Toll Gate Creek, about 350 feet from the Buckley AFB boundary on City of Aurora property. Installation of this off-base well differed from the other wells; it was installed with direct-push techniques to avoid generation of IDW at this location with limited access, as further described below and in Section 2.2.1.5.

The on-base well borings were drilled using a Boart Longyear 66 auger rig with a split-spoon or continuous sampler, supplied and operated by Dakota Drilling, under subcontract to Versar. The borings were drilled to depths ranging from 17 to 55 feet bgs, based on observations of moisture and lithology in the borings and groundwater levels in adjacent wells.

Continuous core samples were collected during the on-base drilling to interpret the hydrogeology and observe potential contamination. The Versar geologist used a PID to measure headspace reading of soil samples, examined the soil samples, and recorded the lithologic interpretations (e.g., lithology, moisture content) and observations of PID readings, staining, and odor, and sampled intervals on the Lithologic Log Form (Appendix C). Headspace readings were measured for soil collected approximately every 5 feet, after the soil was containerized and heated. No analytical soil samples were collected during well installation, because there was no indication of soil contamination. Augers, sampling devices, and any portion of the drill rig that came into contact with subsurface soil were decontaminated upon completion of each well.

On-base monitoring well construction followed industry standards. The wells were constructed inside the 7 1/4-inch outer diameter augers with schedule 40, 2-inch inner diameter PVC, typically including a 10 or 15 foot screen with slot size of 0.010 inches, and a filter pack of 10-20 size silica sand to a height of about 2 feet above the top of the screen. The screen lengths in two wells were different than planned; a length of 20 feet was used in well 11MW03 to screen a thin moist section in addition to the same interval that was screened in adjacent wells, and a length of 8 feet was used in well 11MW02 because a shallow wet zone was observed only a few feet above bedrock (i.e., wet at 11 feet bgs and bedrock at about 14.5 feet bgs). The well screen depths were selected to cross the uppermost water-bearing unit, which was in the alluvium, the

Denver Formation, or both, as indicated on Table 2-1. However, during drilling up- and downgradient of well 1011MW07 (wells 11MW03, 11MW04, and 11MW15), the water-bearing zone was not readily apparent; therefore, the screen intervals were selected based on the adjacent well information. Where the water-bearing zone was first encountered in the alluvium, where possible, the well screen spanned the saturated zone from 2 feet above the water table to the bottom of the hole, which was typically bedrock.

At least 2 feet of 100% sodium bentonite was placed on top of the filter pack to seal the well. The bentonite was hydrated before placement of the grout when the seal was above the top of the water table. After placement and hydration of the seal, the auger rod was removed from the borehole, and a cement-bentonite grout was placed in the annulus from the top of the seal to the ground surface. Ten of the wells were completed with a metal protective casing with a locking lid, surrounded by a 2-feet by 2-feet concrete pad and protective metal posts set in concrete; and five of the wells were completed with flush-mount protective boxes set in concrete.

The boring for off-base well 11MW14 was pushed with 3-inch diameter rods to a depth of 19 feet bgs. This depth was selected based on the lithology, water level, and construction of nearby well LFW-8 (screened from 8.2 to 18.2 feet bgs); the sampled interval in direct-push borehole 11DP69 (10 to 14 feet bgs); and observations of more difficulty pushing at 17 feet bgs (e.g., weathered bedrock), and hard at 19 feet bgs (e.g., unweathered bedrock). The well was constructed with schedule 40, 2-inch inner diameter PVC, and a 10-foot screen with slot size of 0.010 inches from 8.2 to 18.2 feet bgs. A filter pack of 12-20 size silica sand was placed in the annulus to a height of about 3 feet above the top of the screen, and a 5 foot seal of bentonite chips was placed on top of the filter pack and hydrated. The top of the PVC well was sealed with a locking well cap. Upon a license from the city of Aurora, this temporary well may be converted to a permanent well.

All construction details were recorded on Well Construction diagrams (Appendix C), as summarized in Table 2-1.

Monitoring Well Development

The eight monitoring wells installed during the initial phase of the RI were developed on March 18, 19, 20, and 23, 2009. The five wells installed during the second phase were developed on July 2, 6, and 7, 2009. The three wells installed during the third phase were developed on June 23, 25, and 29, 2010.

The wells were developed by surging, bailing, and/or pumping to mobilize and remove fine sediments. Purging continued at each well until a minimum of 5 casing volumes was removed or the well dewatered. Additional volumes were removed when the turbidity readings were high (e.g., over 50 nephelometric units [NTUs]). However, at most wells, even with removal of up to 21 casing volumes, turbidity readings typically remained high and fluctuated with no visual changes in the water, likely due to the instrument's sensitivity to the silt/sand content in the water and indicative of low-yield wells. Conductivity and pH readings typically stabilized before 5 casing volumes were removed.

During initial development, five of the wells dewatered (11MW02 through 11MW04, 11MW14, and 11MW15). The wells that dewatered were developed a second time, after allowing 4 to 6 days for the wells to recover to at least 90% of the pre-development groundwater level. For well 11MW02, 2 gallons were removed before the well dewatered, and 2.25 gallons were removed 4 days later. For well 11MW03, 15 gallons were removed initially, followed by removal of 14 gallons 5 days later. For well 11MW04, 0.4 gallon was removed initially; 0.5 gallon was removed 4 days later. For well 11MW14, about 0.25 gallon was removed initially; about 100 milliliters were removed during development 6 days later. During the initial development of well 11MW15, about 1 gallon was removed before the well dewatered; about 3 gallons were removed when the well was developed a second time, 4 days later.

During development, field parameters, including pH, temperature, conductivity, and turbidity, were measured and recorded on a development log (Appendix C), along with volume and condition of water removed.

Monitoring Well Sampling

The initial phase of monitoring well sampling was conducted on March 23 and 24, 2009. Nine wells were sampled, including the eight newly installed wells (11MW01 through 11MW08) and previously existing well 1011MW07.

During the second phase of investigation, on July 6, 7 and 8, 2009, 11 wells were sampled. These wells included six of the wells installed under the initial phase of the RI (11MW01, 11MW02, 11MW05 through 11MW08), and five new wells (11MW09 through 11MW13). Well 11MW12 was resampled on July 7, because the samples collected from this well on July 6 were outside the acceptable temperature limit when they arrived at the laboratory. The sample from well 11MW12 was analyzed on a rush analytical turnaround, to quickly verify whether PCE concentrations at the base boundary exceeded the CBSG, as indicated by grab groundwater data at this location. Well 11MW12 was sampled again on August 5, 2009 for 1,4-dioxane analysis when it became apparent that installation of the replacement well for 1011MW06 would be delayed, resulting in uncertainty whether 1,4-dioxane was a COC for the off-base investigation.

During the third phase of investigation, 20 wells were sampled. These wells included 13 of the wells installed under the first two phases of the RI (11MW01 through 11MW13); 3 new wells (11MW14 through 11MW16); and 4 previously existing wells 1011MW07, 1011MW04, 710MW03, and LFW-8. All except two of the wells were sampled on June 23, 24, and 25, 2010. Sampling of wells 11MW15 and 11MW14 was delayed until July 1 and July 8, respectively, because of insufficient groundwater in these newly installed wells.

Wells were first purged until a minimum of three well casing volumes were removed and the field parameters stabilized, or until the well dewatered. After a well dewatered, it was allowed to recover enough to sample. During the first sampling round in March 2009, 11MW03 dewatered, and there was insufficient water to purge well 11MW04 (the well volume was 0.19 gallon). For the other wells sampled in March 2009, 2.5 to 7.8 gallons of water were removed from each well. During the second round of sampling in July and August 2009, none of

the wells dewatered, and 3 to 9.75 gallons of water were removed before sampling. During the third (last) round of sampling in June and July 2010, well 11MW14 dewatered after 0.25 gallon was removed; 1.95 to 16.5 gallons were removed from the other wells.

Temperature, pH, conductivity, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity of the purge water were measured and recorded on a Groundwater Sampling Field Data Sheet (Appendix C).

Groundwater from each well was sampled for analysis of VOCs after purging was completed. In addition, samples from wells 1011MW07 and 11MW12 were analyzed for 1,4-dioxane. Tables 2-2 and 2-3 summarize the sampling and analysis.

The groundwater samples were collected in new, clean sample vials provided by the laboratory. The sample containers were marked with their unique identifiers upon collection, and placed in an iced cooler to chill the samples to 6 degrees Celsius (°C) or less for shipment under chain-of-custody to Microbac Laboratories, Inc (Microbac). No preservatives were added to the sample containers.

2.2.1.3 June 2009 Groundwater Grab Sampling and Analysis

Upon completion of the first phase of investigation, which indicated it was feasible to use a direct-push rig in the downgradient area of the PCE plume, a groundwater grab sampling and on-site analysis program was initiated in the on-base portion of the PCE plume area. The proposed work was described in the *Final Addendum to the March 2009 Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar and Prudent, 2009b).

Vista Geoscience, LLC provided the direct-push services, and ChemSolutions Laboratory provided the on-site groundwater analysis. Table 2-4 presents the sampled locations and depths for this and the other two direct-push investigations. The locations are shown on Figure 2-1. Groundwater samples were collected from 30 direct-push locations on June 24 through 26, 2009, at depths ranging from 18.3 to 28.35 feet bgs. Two additional locations were dry, and no samples could be collected. Two samples were collected from monitoring well locations and analyzed by the mobile laboratory. On June 24, 2009, a grab sample was collected from well 11MW05 to assess the comparability of the laboratory results and grab sampling (no purging was conducted), as discussed in Section 3.3.1.1. On June 29, after the total drilled depth at the boring for upgradient well 11MW09 was reached, a grab groundwater sample was collected. These samples were analyzed under the on-site laboratory protocols by ChemSolutions Laboratory.

A combined on-base groundwater sampling and on-site analysis effort was conducted for 3 days. Although 2 days were planned, an additional day was needed to complete the on-base assessment of the extent of the PCE plume. As data were obtained from the on-site laboratory, the data were used to guide the locations of subsequent samples to delineate the downgradient extent of the PCE plume. No soil cores were obtained for lithologic or analytical purposes because the focus was on obtaining analytical groundwater sample data.

Thirty-two (32) test holes were drilled to depths that targeted the shallowest water-bearing zone (alluvium) using direct-push drilling techniques. Initially, the holes were pushed to a depth of about 3 feet below the assumed static water level, based on current measurements in adjacent wells, or to refusal (assumed to represent unweathered bedrock). However, water did not typically enter the hole; therefore, the holes were pushed deeper, to a maximum depth of 28.35 feet bgs. In general, to obtain groundwater for sampling, the holes needed to be pushed about 10 feet deeper than the measured water levels. Because of the variable depth to groundwater, rather than a screen point sampler (which effectively screens a 3- to 4-foot interval) as proposed, groundwater samples were collected from each hole using disposable polyethylene tubing with a stainless-steel check valve, inserted into a 1-inch diameter PVC pipe with a 5-foot screen temporarily placed in the hole.

The initial groundwater sampling locations were between wells 11MW08 and 11MW07. Subsequent locations were upgradient of these wells, with the northernmost points along a silt fence south of Aspen Way. PCE was not detected in the first eight samples (11DP01 through 11DP08). These initial sampling locations were at a spacing of about 50 feet. Because the plume appeared to be narrow (e.g., 35 feet), a sampling grid spacing of 25 feet was also used. Subsequent sampling locations followed the trend indicated by the analytical data: the PCE plume extended downgradient to the west, between wells 11MW06 and 11MW08, then trended southwest, between wells 11MW01 and 11MW02 at the base boundary (Appendix D). The plume appeared to extend off base, toward East Toll Gate Creek.

A groundwater sample was collected from each boring and analyzed on-site in the ChemSolutions mobile laboratory. The samples were analyzed for PCE; its daughter products including TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride; and chloroform. The results were used to guide the location of subsequent groundwater samples as data were obtained from the laboratory. Eight groundwater samples were collected the first day, 9 were collected the second day, and 13 were collected the third day. The groundwater samples could typically be collected in less time than it took to obtain the analytical results; therefore, some of the analytical data confirmed the interpretation of the extent of the PCE, but were not necessary for delineation. Although samples were obtained from three of the locations initially reported as dry, these data may represent groundwater diluted with rainwater because severe storms occurred during the field work. After sampling was completed, the borings were abandoned by filling them with bentonite chips, in accordance with the State of Colorado well abandonment procedures. These procedures are described in 2 Colorado Code of Regulations (CCR) 402-2 (State of Colorado Office of the State Engineer, 2005).

The results of the on-base grab groundwater sampling and on-site analysis were used to determine appropriate locations for two permanent monitoring wells within the PCE plume (11MW12 and 11MW13), as described above in Section 2.2.1.2. These data, including those from the on-base grab groundwater sampling and sampling of all monitoring wells installed to date under the RI, were used to plan an off-base investigation program, as described in the *Final Second Addendum to the March 2009 Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar and Prudent, 2009c).

2.2.1.4 February 2010 Groundwater Grab Sampling and Analysis

Investigation of the off-base portion of the PCE plume was delayed for several months due to the need to obtain additional funding, City of Aurora access issues, and ground/weather conditions. The off-base groundwater grab sampling and on-site analysis program was initiated on February 17, 2010. Site Services provided the direct-push services, and ChemSolutions Laboratory provided the on-site groundwater analysis, although for security and access reasons, the laboratory trailer was parked on-base, on the asphalt parking lot area south of former Building 1011. Sample transfer from the field to laboratory personnel was through the Buckley AFB boundary fence and by driving between the on-base and off-base locations.

The planned approach was to collect groundwater samples from the north side of East Toll Gate Creek near the known plume area, before sampling groundwater on the south side; therefore, Site Services attempted to direct the direct-push track rig, a Geoprobe 7730DT, with a wireless remote control to the north investigation area. After the rig reached the base of the creek bed, it was determined the banks were too steep and slippery to continue up the north bank, and an International hauler was used to pull the rig back up the south bank of the creek. Therefore, during this mobilization, grab groundwater samples were collected only on the south side of East Toll Gate Creek. Table 2-4 presents the sampled locations and depths for this and the other two direct-push investigations. The locations are shown on Figure 2-1. The groundwater samples were collected from 22 locations on February 17 and 18, 2010, at depths ranging up to 19 feet bgs. One additional location was dry, and no samples could be collected. The combined off-base groundwater sampling and on-site analysis effort was conducted for 2 days. As data were obtained from the on-site laboratory, the data were used to guide the locations of subsequent samples to delineate the downgradient extent of the PCE. No soil cores were obtained for lithologic or analytical purposes because the focus was on obtaining analytical groundwater sample data.

Twenty three (23) holes were drilled to depths that targeted the shallowest water-bearing zone (alluvium) using direct-push drilling techniques. Initially, the holes were pushed to depths of 13 to 14 feet, about 4 feet below the assumed static water level. However, at four of the initial locations, groundwater did not enter the hole; therefore, most holes were pushed to a depth of 19 feet bgs. A stainless steel screen point sampler (SP15/SP16, which screens about a 4-foot interval) was used, and groundwater samples were collected from inside the sampler using new disposable ¼-inch diameter polyethylene tubing at each location.

The initial groundwater sampling locations were at the three locations proposed in the Final Second Addendum to the Final QPP for Site 11 RI south of the creek, which were expected to be near the downgradient end of the plume. Subsequent locations were to the northwest and southwest, along the bank of the creek, and also to the south, up to about 70 feet from the creek center. Distances between sample locations ranged from approximately 20 to 40 feet.

A groundwater sample was collected from each boring and analyzed on-site in the ChemSolutions mobile laboratory. The samples were analyzed for the same suite of VOCs analyzed in the on-base samples: PCE; its daughter products including TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride; and chloroform. The results were used to guide the location of

subsequent groundwater samples as data were obtained from the laboratory. Nine groundwater samples were collected the first day, and 14 were collected the second day. However, two of the samples collected the second day were at two different depths from a location (11DP42) that was dry the previous day (the tubing was left in the hole). The groundwater samples could typically be collected in less time than it took to obtain the analytical results; therefore, some of the analytical data confirmed the interpretation of the extent of the PCE, but were not necessary for delineation. After sampling was completed, the borings were abandoned by filling them with bentonite chips, in accordance with the State of Colorado well abandonment procedures. These procedures are described in 2 CCR 402-2 (State of Colorado Office of the State Engineer, 2005).

Following this phase of data collection, because crossing the creek did not appear to be feasible, other options to conduct the investigation on the north side of East Toll Gate Creek were evaluated. It was decided that the direct-push rig would travel from Airport Boulevard near East Hughes Drive to the investigation area, about 1.5 miles overland, including crossing a storm drain ditch from Buckley AFB. This required additional coordination with the City of Aurora, commitment to restore all areas disturbed by this work, and rescheduling the work when the weather/ground conditions were dry enough.

2.2.1.5 May 2010 Groundwater Grab Sampling and Analysis

Upon suitable weather and ground conditions, the investigation on the north side of East Toll Gate Creek was initiated on May 26, 2010. Site Services provided the direct-push services, temporarily installing aluminum ramps for the Geoprobe 7730DT and support truck to cross the storm drainage ditch. ChemSolutions Laboratory provided the on-site groundwater analysis. The laboratory trailer was parked on-base, on the asphalt parking lot area south of former Building 1011. Sample transfer from the field to laboratory personnel was primarily through the Buckley AFB boundary fence.

The combined off-base groundwater sampling and on-site analysis effort north of East Toll Gate Creek was conducted for 2 days, on May 26 and 27, 2010. Table 2-4 presents the sampled locations and depths for this and the other two direct-push investigations. The locations are shown on Figure 2-1. Twenty-seven (27) holes were drilled to depths that targeted the shallowest water-bearing zone (alluvium) using direct-push drilling techniques. All except two holes were pushed to a depth of 14 feet bgs, about 4 feet below the assumed static water level; these two other holes were pushed to depths of 18 and 19 feet bgs. Groundwater grab samples were collected from 25 locations using a stainless steel screen point sampler, and disposable ¼-inch diameter polyethylene tubing connected to a peristaltic pump. Two additional locations were dry, even after leaving the holes open overnight, and no samples could be collected.

The initial groundwater sampling location (11DP56) was at the initial location proposed in the Final Second Addendum to the Final QPP for Site 11 RI (Versar and Prudent, 2009c). Subsequent locations were selected to bound the edges of the PCE plume, primarily to the west. Distances between sample locations ranged from approximately 20 to 50 feet. As data were obtained from the on-site laboratory, the data were used to guide the locations of subsequent samples to delineate the downgradient end of the PCE plume. No soil cores were obtained for lithologic or analytical purposes.

The groundwater samples were analyzed on-site in the ChemSolutions mobile laboratory, for the same six VOCs analyzed in the other grab groundwater samples. Thirteen groundwater samples were collected the first day, and 12 were collected the second day. One of the samples collected the second day was from a location (11DP59) that was dry the previous day (the tubing was left in the hole). After sampling was completed, the borings were abandoned by filling them with bentonite chips, in accordance with the State of Colorado well abandonment procedures. These procedures are described in 2 CCR 402-2 (State of Colorado Office of the State Engineer, 2005).

The results of this phase of grab groundwater sampling and on-site analysis were used to determine a location for an off-base well north of the creek that could be used to monitor the end of the PCE plume. As described above in Section 2.2.1.3, this well was installed adjacent to 11DP69 on the second day of sampling using the direct-push rig.

2.2.1.6 Off-Base Surface Water and Sediment Sampling and Analysis

After the on-site analysis of the off-base grab groundwater samples collected south of East Toll Gate Creek was nearly complete, surface water and sediment sampling locations in the off-base area of the creek were selected. The locations are shown on Figure 2-1. The locations were selected based on the interpretation of the plume location from the direct-push groundwater samples collected south of East Toll Gate Creek (groundwater samples north of the creek had not yet been collected) and the surface water and groundwater flow. One location was near the base boundary, about 150 feet upstream (southeast) from where the inferred center of the PCE plume appeared to intersect the creek. One location was near the approximate inferred plume's intersection with the creek. The third location was about 200 feet downstream (northwest) of the inferred primary intersection of the plume and the creek. (Groundwater data subsequently collected north of the creek indicates the plume alternately trends toward and away from the creek.) Access to the sampling locations was difficult because of the steep, slippery banks and vegetation overgrowth; these conditions further deteriorated because of snow that began to fall during the sampling.

The surface water and sediment sampling was conducted on February 18, 2010. The surface water and sediment sampling procedures were in accordance with the standard operating procedure (SOP) included in the Final Second Addendum to the Final QPP for Site 11 RI (Versar and Prudent, 2009c). Samples were collected, beginning at the downstream location, directly into the sample containers. In addition to collecting samples for analysis, the width and depth of the surface water and water quality parameters (temperature, pH, conductivity, DO, ORP, and turbidity) were measured in water that was collected from each of the sample locations.

Surface water and sediment samples were analyzed by the mobile laboratory for six VOCs, and also submitted for fixed-base laboratory analysis of a full suite of VOCs. Analytical suites were the same as specified for the groundwater samples, which differed between the mobile laboratory analysis and the fixed-base laboratory analysis, as described in Section 2.3. The samples were collected in new, clean sample vials provided by the laboratory. The sample containers were marked with their unique identifiers upon collection, and placed in an iced

cooler to chill the samples to 6°C or less for shipment under chain-of-custody to Microbac. No preservatives were added to the sample containers.

2.2.1.7 Water-Level Measurements

Water-level measurement rounds were conducted on March 5, 2009 before the initial RI drilling program; on April 8, 2009 after the initial RI drilling program; on July 10, 2009 after the second phase of the RI drilling; and on June 23, 2010 after the third phase of RI drilling, as summarized in Table 2-3. In addition, because water levels in wells 11MW14 and 11MW15, installed during the third phase of RI work, had not stabilized, additional water-level measurements for these and the adjacent wells (LFW-8 and 1011MW07) were collected periodically through September 3, 2010 for the on-base wells (11MW15 and 1011MW07), and September 10, 2010, for the off-base wells (11MW14 and LFW-8).

Thirteen (13) wells were included in the first water-level measurement round (MW-4 couldn't be unlocked), 29 were included in the second round, 34 were included in the third round, and 37 were included in the fourth round. Adjacent Site 2 Oil Pit and Site 3 Base Landfill wells, as indicated on Table 2-3, were included in these measurement rounds. Water-levels were also measured during well development, well sampling, and the drilling programs. During the initial RI drilling program, estimated groundwater elevations were used to refine the initially proposed location of the well upgradient of the elevated PCE concentration in former well 1011MW06. Water levels were measured to the nearest 0.01 foot from the surveyed measuring point.

2.2.1.8 Surveying

On March 23, 2009, a Colorado-licensed professional surveyor from Thomas Survey Services surveyed the locations and ground and measuring-point elevations of the eight new wells. After the second phase of investigation, on July 6, 2009, Thomas Survey Services surveyed the locations and ground elevation of the direct-push locations, and the locations and ground and measuring-point elevations of the five new wells. On May 28, 2010, the off-base sampling locations, including the grab groundwater and surface water/sediment sampling locations and the off-base temporary well (11MW14) were surveyed. (Under the USACE-Kiewit contract, the two new on-base wells (11MW15 and 11MW16) were surveyed on July 1, 2010.

Horizontal locations were determined to the nearest 0.1 foot and elevations to the nearest 0.01 foot. Reference locations, tied into the State Plane Coordinate system, were used to convert all location coordinates to the State Plane system. Appendix E contains the location and elevation data.

2.2.1.9 Investigation-Derived Waste

IDW for the Site 11 field work was limited to soil from drilling activities, decontamination water, development and purge water, and sampling related trash (i.e., bailer, rope, gloves, etc.). IDW was segregated by media type. All soil cuttings were containerized in

55-gallon drums with a water-tight lid, labeled as IDW, and staged on the asphalt parking lot within Site 11 (south of former Building 1011). All development, purge, and decontamination water was containerized, labeled as IDW, and staged at each well. Trash, including but not limited to gloves, paper towels, plastic bags, disposable bailers, and rope, was disposed as sanitary waste.

For each of the three phases of drilling, a composite sample of the soil IDW was obtained from the drums and analyzed for VOCs, eight RCRA metals, ignitability, and corrosivity/pH. The sample collected for the first phase of drilling was also analyzed for reactivity. Water IDW was managed and disposed of based on the analytical results of the associated groundwater samples.

The IDW was picked up from Buckley AFB after each phase of investigation (on May 4 and November 10, 2009; and August 5, 2010) and disposed, including 8 drums of water IDW and 20 drums of soil IDW for the initial phase of investigation, 11 drums of water IDW and 12 drums of soil IDW for the second phase of investigation, and 18 drums of water IDW and 5 drums of soil IDW for the third phase of investigation (including drilling IDW under a USACE funded project). The soil IDW was profiled, transported, and disposed of at the DADS by ET Technologies. ET Technologies disposed of the IDW water at Conservation Services where it was solidified. Non-hazardous waste manifests were signed by a Buckley AFB representative, and are contained in Appendix F.

2.2.2 Chronology of Investigation

On February 26, 2009, Versar met with Buckley AFB and contractor personnel at the site to review the proposed well locations with respect to the redevelopment activities in the area and asbestos waste near the base boundary; and staked the proposed well locations. The Final Site 11 RI QPP was submitted on March 4, 2009. Versar conducted a water-level measurement round on March 5, 2009. Buckley AFB clearance (AF Form 103) was approved on March 5, 2009. The initial phase of well installation began on March 10, and was completed on March 17, 2009. The eight new wells were developed on March 18 through 20, and March 23, and the new and existing wells were sampled on March 23 and 24, 2009. The wells were surveyed on March 23, another water-level measurement round was conducted on April 8, and the IDW was removed from the base on May 4, 2009.

Versar prepared a summary, including figures and tables, of the initial phase of investigation, and a Buckley AFB TWG meeting was held on May 14, 2009 to discuss the second phase of investigation. The proposed investigation, as presented in the *Final Addendum to the March 2009 Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar, 2009b), included a groundwater grab sampling and on-site analysis program to delineate the downgradient extent of the PCE plume, followed by installation of additional monitoring wells. The Buckley AFB TWG concurred with the addendum on June 22, 2009. Buckley AFB clearance was approved on June 18, 2009, and the on-site laboratory subcontractor mobilized on June 23, 2009. The groundwater grab sampling and on-site laboratory analysis was conducted from June 24 through 26, 2009. Based on these results, Versar proposed five well locations to monitor the plume; these monitoring wells were installed

from June 29 through July 2, 2009. On June 29, a grab sample was collected from the boring for well 11MW09 for same day analysis by ChemSolutions to verify the upgradient end of the plume had been delineated. The new wells were developed on July 2 and 6, and the new and existing wells were sampled on July 6, 7, and 8, 2009, with the sample analysis from the boundary well (11MW12) rushed. The wells were surveyed on July 6, and a water-level measurement round was conducted on July 10, 2009.

When the grab sampling groundwater data indicated an off-base investigation was needed, the Air Force obtained additional funding for this investigation and access to the off-base property from the City of Aurora, and Versar prepared a second addendum describing the proposed off-base investigation for the third phase of investigation. Buckley AFB TWG comments on the addendum recommended sampling the boundary well for 1,4-dioxane before the off-base investigation was conducted, to determine whether the off-base samples should be analyzed for this potential contaminant, rather than waiting for installation of the replacement well for 1011MW06. Versar sampled the boundary well for 1,4-dioxane on August 5, 2009. The *Final Second Addendum to the March 2009 Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation* (Versar, 2009c) was submitted on August 14, 2009. The IDW from the second phase of investigation was not immediately removed from the base, because it was assumed it would be removed at the same time as the IDW from the third phase of investigation, which initially appeared imminent. The off-base investigation work was scheduled for September 23, 2009; however, implementation of this third phase of field work was significantly delayed because of access issues, as described below.

A final signed access agreement was received from the City of Aurora on September 15, 2009, but certain new conditions on the work were imposed. To initially address the issues, Versar, Buckley AFB, and City of Aurora personnel met at the off-base investigation area on September 30. Versar subsequently contacted other adjacent property owners for access, met with a direct-push contractor at the site on October 15 for input on crossing East Toll Gate Creek, and submitted an access plan to the City of Aurora on October 21, 2009. The access plan was approved by the City of Aurora on October 30, 2009; however, because of the continual snow and wet conditions at the site, the work was not conducted until February 17, 2010. During this delay, the IDW from the second phase of investigation was removed from the base, on November 10, 2009. In addition, Versar periodically checked the conditions at the site, cleared snow from the north-facing bank and temporarily covered it to prevent additional snow accumulation, attempted to reschedule the work multiple times, and obtained an amendment to the access agreement with the City of Aurora to extend the agreement for a term of 180 days, beginning on January 22, 2010.

The third phase of investigation was initiated on February 17, 2010, beginning with direct-push and groundwater grab sampling on the off-base property south of East Toll Gate Creek, and surface water and sediment sampling in the creek. The data from this investigation were submitted to the Buckley AFB TWG, and it was determined another attempt to reach the north side of East Toll Gate Creek to collect groundwater samples and install a temporary well was warranted. A new route to access the area was investigated. When the city of Aurora was notified of the new plan, they requested an additional restoration plan. The work was scheduled for April 2010; however, it was postponed until May 2010 because of wet ground conditions.

The off-base investigation north of East Toll Gate Creek was conducted from May 26 through 28, 2010. This work included direct-push and groundwater grab sampling, installation of a temporary well, and surveying of all off-base sampling locations. A summary of the results was submitted to the Buckley AFB TWG in June. It was determined the remaining RI work would include a sampling and water-level measurement round, after the installation of two on-base wells under a USACE contract. These two wells were installed on June 21 and 22; the water-level measurement round was conducted on June 23; and sampling was conducted from June 23 through July 8, 2010. Because water levels in two of the new wells had not stabilized, they were measured through September 3 and 10, 2010, for wells 11MW15 and 11MW14, respectively. The IDW was removed from Buckley AFB on August 5, 2010, and disposed.

2.2.3 Field Quality Control

Field QC samples were collected according to the requirements and procedures described in the Final Site 11 RI QPP (Versar and Prudent, 2009a) and the two addenda to the QPP (Versar and Prudent, 2009b, 2009c). Field QC samples included field duplicates, matrix spikes (MS), matrix spike duplicates (MSD), and ambient blanks, as summarized on Table 2-2. Disposable sampling equipment was used; therefore, no field equipment blanks were collected. For the off-site laboratory analysis of groundwater samples, a minimum of one field duplicate sample was collected for every 10 samples collected. One MS/MSD pair was collected for every 20 samples collected. One ambient blank was collected during each of the three phases of sampling.

No field QC samples were collected for the surface water and sediment samples from East Toll Gate Creek, for either the off-site or on-site (mobile) laboratory, because of the difficulty in obtaining a homogeneous VOC sample that would be split for QC analysis (e.g., duplicates, MS, MSDs). In addition, analytical results from the on-site laboratory analysis could be used to provide an assessment of the variability in the analytical results. For the groundwater grab samples analyzed by the on-site laboratory, field QC samples included two field duplicates. Because these are not definitive data, and monitoring wells were subsequently installed and sampled to obtain definitive data, no additional field QC samples were collected during the grab groundwater sampling. The assessment of the field QC samples is included in Appendix G.

2.3 LABORATORY ANALYSIS

Microbac in Marietta, Ohio, analyzed the monitoring well groundwater, surface water, sediment, and IDW soil samples collected during the Site 11 field work, as is referred to as the fixed-base laboratory. ChemSolutions Laboratory analyzed the groundwater grab samples, including a grab sample collected before completion of well 11MW09, a grab sample from well 11MW05, and also the surface water and sediment samples. ChemSolutions Laboratory is referred to as the on-site or mobile laboratory. Table 2-2 summarizes the analyses.

All groundwater grab samples, groundwater samples from the monitoring wells, surface water samples, and sediment samples were analyzed for VOCs using EPA Method 8260B. However, the on-site analytical suite only included six VOCs: PCE; TCE; cis-1,2-DCE; trans-1,2-DCE; vinyl chloride; and chloroform. Groundwater samples from two monitoring wells,

1011MW07 and 11MW12 were also analyzed for 1,4-dioxane by EPA Method 8270C. Soil IDW samples were analyzed for VOCs by EPA 8260B, eight RCRA metals by EPA Method 6010B, corrosivity/pH by EPA Method 9045D, ignitability by EPA Method 1010, and, for the initial phase, reactivity by SW7.33/7.34.

Analytical procedures were conducted in accordance with the methodology set forth in the SAP Addendum (contained in the Final Site 11 RI QPP [Versar and Prudent, 2009a]), as required by the Basewide Quality Assurance Project Plan (QAPP) (URS, 2004c), and the AFCEE QAPP Version 3.1 (AFCEE, 2001).

Versar has reviewed the groundwater, surface water, sediment, and soil analytical data in accordance with AFCEE protocols, as described in the AFCEE QAPP (AFCEE, 2001) and Basewide QAPP for Buckley AFB (URS, 2004c). The data presented in this report are qualified on the basis of this review. Appendix G contains the data evaluation summary.

2.4 DATA EVALUATION

As described in the Final Site 11 RI QPP (Versar and Prudent, 2009a) and addenda to the QPP (Versar and Prudent, 2009b, 2009c), the data collected during the Site11 RI tasks and assessed under this project include:

- Groundwater-level, geological, and hydrogeological information
- Field measurements (organic vapors, temperature, pH, DO, ORP, conductivity, turbidity)
- Groundwater, sediment, and surface water analytical data generated by an on-site (mobile) laboratory
- Groundwater, sediment, and surface water analytical data generated by a fixed-base laboratory
- Survey data

The first three types of data were collected using real-time measurement technologies or information and used to refine the field program and reduce uncertainties. The groundwater-level and geological information were used to determine the groundwater flow direction in the investigation areas, potential preferential flow pathways, and the appropriate locations and construction for new groundwater monitoring wells, and contaminant extent and migration. Field screening measurements were used to provide an indication of potential contamination in soil and groundwater. Field water-parameter data also help support evaluation of remediation technologies, as needed. The mobile laboratory data were used to preliminarily determine the location and extent of PCE and associated contamination, guide the locations of subsequent samples, and determine the locations for monitoring wells. The survey information for the direct-push groundwater sample locations, surface water and sediment sample locations, and monitoring wells were used to develop maps of the sample locations, potentiometric surface, groundwater plumes, and contaminant concentration maps that will be used to facilitate

decisions. The analytical data were verified and validated in accordance with AFCEE protocols, as described in the AFCEE QAPP (AFCEE, 2001) and Basewide QAPP for Buckley AFB (URS, 2004c). Field and validated laboratory data have been evaluated to assess the nature and extent of contamination and potential migration.

In accordance with the Final Site 11 RI QPP (Versar and Prudent, 2009a) and addenda to the QPP (Versar and Prudent, 2009b, 2009c), the CSM; applicable or relevant and appropriate requirements (ARARs) and to-be considered (TBC) advisories, criteria, or guidance; background conditions; and assessment of risk were considered in determining whether the site has been adequately addressed, whether further work is required, and likely/potential response actions. Field and validated laboratory data collected under this RI were evaluated to assess the nature and extent of contamination previously detected in wells 1011MW06 and 1011MW07, and whether the contaminants are of concern to human health or the environment.

Versar compared the analytical groundwater, surface water, and sediment analytical results to chemical-specific ARARs and TBC criteria. TBC criteria can be used to screen sites, but are not considered regulations or guidance. The chemical-specific ARARs for Site 11 are limited to federal and Colorado standards for groundwater and surface water quality. Chemical-specific ARARs for groundwater are the CBSGs, under Regulation 41 (5 CCR 1002-41) (CDPHE, 2009a).

Based on the Colorado Water Quality Control Commission Regulation No. 38 (Effective March 30, 2009) (CDPHE, 2009b), it is interpreted the applicable water quality standards for East Toll Gate Creek are the Fish Ingestion standards. The standards are listed in Regulation No. 31, The Basic Standards and Methodologies for Surface Water (5 CCR 1002-31) (CDPHE, 2008).

Currently, there are no federal or state chemical-specific ARARs for sediment at Site 11. Potential chemical-specific TBCs for sediment include EPA and CDPHE risk-based soil screening levels. The Hazardous Materials and Waste Management Division of CDPHE proposed a soil standards policy in 1997 for making decisions involving the characterization and remediation of sites where regulated constituents of hazardous substances are present in soil (CDPHE, 1997). CDPHE has periodically updated a table containing the standards, with the most recent values released in a table dated December 2007, and identified as CSEVs, rather than the previously referenced Soil Remediation Objectives (SROs). This table includes generic soil standards for residential, commercial, and industrial land uses, groundwater protection, and leachate reference concentrations. However, state soil standards have not yet been promulgated; therefore, these are TBC criteria and not ARARs. EPA RSLs (EPA, 2010a) are also TBCs for Site 11 sediment; these screening levels are Agency guidelines, not legally enforceable standards, which can be used for site screening and as initial cleanup goals if applicable. The sediment data collected under this RI were compared to the residential CSEVs (December 2007) and the EPA RSLs (May 2010).

3.0 INVESTIGATION RESULTS

This section presents the field observations, site geology and hydrogeology, analytical results, and an assessment of the information. Section 3.1 summarizes the field observations; and Section 3.2 summarizes the geology, groundwater, and surface water at Site 11, incorporating data collected during this field program. Section 3.3 presents the analytical results, and Section 3.4 presents an assessment of the data. These discussions are generally subdivided by plume area, because groundwater contamination occurs in two distinct areas of the site, with different characteristics. These two areas are distinguished in this report as the PCE Plume and the North Plume. They related to the groundwater contamination identified during the Triad SI in wells 1011MW06 and 1011MW07, respectively.

3.1 SUMMARY OF FIELD OBSERVATIONS

During the RI, field observations included visual observations and screening with a PID during drilling to assess soil contamination. During the drilling of the 16 monitoring wells installed under this RI (includes two wells installed under a USACE-funded contract), there was no indication of soil contamination that may have indicated a source of contamination. No stained soil or soil with an odor was observed. PID readings were low, both for soil samples screened during drilling, and headspace measured at monitoring wells.

At the wells drilled to investigate the PCE plume, slightly elevated PID readings for soil (the highest was 1.7 ppm) appeared to be associated with groundwater contamination (11MW02, 11MW05, 11MW11, 11MW12, and 11MW13), based on the soil depths. A screening measurement of 0.2 to 0.4 ppm at the surface of 11MW11 was likely associated with the adjacent pavement and vehicle access.

At the well drilled downgradient of well 1011MW07, well 11MW15, soil from the 0- to 5- and 5- to 10-feet-bgs intervals had PID headspace measurements slightly above the initial background measurement of 4 ppm; these measurements were 6.2 and 5.8 ppm, respectively (the recorded measurements decreased with depth to 0.0 ppm for the 30- to 35-feet-bgs interval.) During drilling of well 1011MW07 during the Triad SI, significantly higher PID readings were measured for the soil (23 to 261 ppm associated with staining or odor); however, no VOCs were detected above screening levels in the soil. Therefore, because the PID measurements were only slightly above background (e.g., 1.8 and 2.2 ppm), no analytical soil samples were collected from the boring for well 11MW15.

3.2 SITE GEOLOGY AND HYDROGEOLOGY

This section describes the Site 11 setting and features, and the geology and hydrogeology. Sections 3.2.1 and 3.2.2 present plume area-specific information in more detail.

Site 11 is in an area that slopes to the southwest toward East Toll Gate Creek, although when this area was first developed in the 1940s, the area immediately south of former Building 1011 was leveled to construct the paved access and parking area, and an area immediately south of Aspen Way was also apparently leveled by importing fill material.

Stormwater from the paved area drains into two catch basins that convey water into pipes that discharge north and south of Aspen Way (Figure 2-1). Two minor drainages have been present between former Buildings 1011 and 710; they combine and extend south-southwest towards East Toll Gate Creek. During recent improvements to Aspen Way and adjacent ongoing construction, the drainage underneath Aspen Way was improved. Runoff in the drainages is conveyed along the west side of the Boresight Tower Road about 700 feet towards East Toll Gate Creek.

Previous interpretations of the site-specific geology and hydrogeology for this area were presented in the Final Site 11 RI QPP, with information from the initial phase of the RI incorporated in the addenda to the QPP (Versar and Prudent, 2009b, 2009c). This section incorporates information from all three phases of the RI to present an updated interpretation. Figure 2-1 shows the locations of the wells and direct-push sampling locations, and the locations of the geologic cross-sections. The June 2010 potentiometric surface is shown on Figure 3-1. Cross-sections through Site 11, focusing on the areas of groundwater contamination, are included as Figures 3-2 through 3-5. Lithology logs are included in Appendices A and C. Although some of the direct-push sampling locations are shown on the cross sections, water-level measurements for these locations were not used, because of the time typically required for the water levels to stabilize, in addition to the lack of time-concurrent water-level data for the monitoring wells. In addition, no lithology information was obtained for the direct-push locations, although, as shown on Table 2-4, for some of the locations, an approximate depth to bedrock could be assumed where it became more difficult to push.

The two primary stratigraphic units penetrated at Site 11 are unconsolidated deposits, which include fill soil and Quaternary-age unconsolidated alluvial sediments and loess, and the underlying Late Cretaceous to Paleocene-age Denver Formation bedrock. Unconsolidated deposits encountered in the borings drilled beneath Site 11 are primarily fine- to coarse-grained sand, silty and sandy clay, and sandy silt. The unconsolidated deposits are underlain by weathered bedrock. At many locations, the interface between unconsolidated surficial deposits and bedrock can appear to be transitional, attributed to weathering. Within the borings drilled at Site 11, the Denver Formation consisted predominantly of olive-gray, silty, fine- to medium-grained sandstones and claystones. Typically, the bedrock was weathered, olive to dark gray claystone, with occasional iron staining on fractures; red brown sandstone; and fine- to medium-grained silty sandstone. The unweathered Denver Formation included a blue-gray claystone and siltstone locally known as the "Denver Blue". The "Denver Blue's" upper surface is not a stratigraphic horizon, but rather an irregular weathering/alteration zone that is often transitional. The bluish color was observed to change to a predominantly grayish color after exposure to air. During the RI drilling, the "Denver Blue" was identified at seven locations, at initial depths ranging from 31 feet bgs (11MW11) to 52 feet bgs (11MW05) (Appendix D).

As described above, the contact between the alluvium and Denver Formation is often difficult to determine, and it is particularly difficult at this site because of the numerous alterations to the ground surface beginning in the 1940s, with construction of Building 1011, the parking lot, other nearby buildings, associated utilities, and access roads, in addition to the raising of the ground surface south of Aspen Way, where building debris has been uncovered during invasive work to install a new sewer line. The depth to bedrock has been interpreted as between 7 feet bgs (well 11MW10) to 35 feet bgs (11MW16). Bedrock is shallowest north of

Aspen Street and south of Building 1011; portions of this area may have been historically leveled. The thickest alluvium generally is present in the southern area of Site 11. The thickness and composition of the alluvial deposits are influenced by the northwest-southeast trending ridge along the northeast side of the site, and the East Toll Gate Creek valley/drainage area, which trends southeast to northwest along the southwest edge of Site 11. As described in Section 1.2.5, the eolian (windblown) deposits, which are collectively referred to as alluvium with the alluvial deposits in this report, are thicker in the topographically high areas relative to the stream valleys. In general, the alluvium associated with stream deposition is at the maximum thickness in the central portions of the valleys and decreases in thickness along the flanks.

The hydrogeology at the site is complex and varies across the site. In much of the on-base Site 11 area, the unconsolidated materials are mostly unsaturated, and the groundwater is in bedrock. In the north area of the site, the bedrock is primarily claystone, and does not readily yield water. For example, no wet zones (only intermediate between dry and moist conditions, referred to as "dry-moist") were observed to a total depth of 60 feet in Triad SI wells 1011MW02, 1011MW03, and 1011MW04. These wells were screened from about 45 to 60 feet bgs across generally dry-moist claystone and lesser amounts of sandstone, and dewatered during development. Similarly, in RI wells 11MW03, 11MW04, and 11MW15, no wet zones were observed to total depths that ranged from 35 to 55 feet bgs; however, groundwater later slowly entered the wells. In the central-eastern area of Site 11, groundwater is readily produced from weathered bedrock sandstone (such as 11MW05, 11MW06, 11MW09, 11MW10, and 11MW11). In the southern-southwest areas of the site, groundwater is unconfined within alluvial deposits, including those in an alluvial paleochannel, that also readily produce water. During a previous investigation in March 2005 (Section 1.3.2.6), perched groundwater occurred about 18 to 20 feet bgs near the eastern-northeast area of the site, upgradient from the Building 710 LNAPL area ("LDC-" wells).

Table 3-1 contains the RI groundwater-level measurements. A comprehensive set of water-level data are included in a table in Appendix E. Within the on-base portion of Site 11, the June 2010 potentiometric surface ranged from 8.34 feet bgs in well 11MW01, to 26.93 feet bgs in well 11MW09. (Water at well 11MW15 was deeper because it had not yet stabilized in this new well.) In the upgradient background well 1011MW01, the potentiometric surface was 38.75 feet bgs. In the off-base area of Site 11, the June 2010 potentiometric surface was 10.11 feet bgs in LFW-8; the water level had not yet stabilized in well 11MW14. The water level in well 11MW14 was at its highest level of 11.19 feet bgs when last measured on September 10, 2010; however, the water level in LFW-8 had dropped 1.79 feet during that time period, likely because of the lack of precipitation. The shallowest groundwater is in the south-southwest areas of the site, in the wells within the East Toll Gate Creek valley. The deepest groundwater is in the northeast area of the site, adjacent to former Building 1011, and upgradient (northeast) of the site, in the topographically highest well, along a southeast-northwest trending ridge. In June 2006, during the Triad SI, the potentiometric surface in the Building 1011 AOC (Site 11) wells ranged from 2.43 to 4.12 feet lower. The difference in well 1011MW07 was less (0.47 feet); however, this was because the water in this well had not yet stabilized after installation.

Figure 3-1 shows the June 2010 potentiometric contours, groundwater elevations, and flow direction, which incorporate information from adjacent site wells. The general direction of groundwater flow is to the southwest-west. However, the data also show localized south-southeast flow converging with the southwest flow towards the central southern area of the site (well 11MW16), which is likely attributable to groundwater flow through the clean, fine to coarse-grained sand deposits in the paleochannel in this area. The hydraulic gradient in this paleochannel area is estimated as 0.009 ft/ft in a southwest direction, indicating a relatively high conductivity compared to other areas of the site. In the off-base area, the hydraulic gradient is slightly steeper, about 0.012 to 0.014 ft/ft, in a west-northwest direction. In the north area of the site, where groundwater is present, the hydraulic gradient is steepest, about 0.05 to 0.06 ft/ft in a southwest direction. This steep gradient is consistent with the apparent low hydraulic conductivity of the bedrock in this area.

3.2.1 PCE Plume

In the southern Site 11 area, where the depth to bedrock is the greatest, well 11MW16 is interpreted to be within a narrow (about 50 feet wide) alluvial paleochannel that trends generally west-southwest through Site 11 and off base, with a meandering trend that includes bends to the northwest (Figures 3-3 and 3-6). This interpretation is based on all data (geologic, hydrologic, and chemical). This paleochannel was initially identified in former well 1011MW06 during the Triad SI in 2006. It is not present in the source area of the PCE plume, where the alluvium is unsaturated (Figure 3-2). Upgradient of former well 1011MW06, the paleochannel may trend towards the LNAPL well area, or not be present. As discussed in Section 4.3, it appears to be a preferred pathway for migration of PCE in groundwater at Site 11.

In the boring for well 11MW16, the primary water-bearing zone included a 3.5-feet thick, loose, fine- to medium-grained sand with coarse sand zones, overlain primarily by sandy clay (Appendix D), with a water level of about 17.8 feet bgs. Underlying this alluvial water-bearing zone, at about 35 feet bgs, was weathered, blocky, claystone bedrock, with iron-stained fractures. At former well 1011MW06, which was about 40 feet upgradient (northeast) of well 11MW16, the water-bearing zone consisted of a loose, medium- to coarse-grained sand, about 8 feet thick, although the water level in 2006 was about 2 feet below the top of the sand, about 22 feet bgs. This alluvial sand was underlain by clay with high plasticity (interpreted as weathered Denver Formation) at about 28 feet bgs. In the downgradient direction, in well 11MW13, the water-bearing zone is about 17 feet thick, including sandy clay overlying a 5-feet thick, fine- to medium-grained sand that generally coarsened downwards. At 31.2 feet bgs, it was underlain by weathered, claystone bedrock, with iron-stained fractures. At the base boundary, the well near the center of the PCE plume, well 11MW12, did not have the characteristic alluvial sand that was observed in the other central wells in the PCE plume. The water-bearing zone in this well (about 10 feet thick) consisted of silty clay, sandy silt, and a minor amount of clayey, silty, fine-grained sand, including about 1 foot of weathered sandstone bedrock, to about 19 feet bgs (Figures 3-2 and 3-4). In the central wells in the on-base portion of the alluvial paleochannel, the June 2010 potentiometric surface ranged from 9.23 feet bgs in downgradient well 11MW12, to 17.80 feet bgs in upgradient well 11MW16.

In the off-base area of the PCE plume, no lithology samples were obtained during the RI, although observations during the direct-push work suggested an alluvial paleochannel continued through the area north of East Toll Gate Creek. This was indicated at direct-push locations where groundwater quickly entered the hole and appeared clear, the hole appeared to cave in, sand grains were recovered during sampling, and higher PCE concentrations generally were detected. About 120 feet from the base boundary, based on the topography, relative water levels, and distribution of PCE concentrations, there may be a geological feature (e.g., cemented or low permeability/ transmissivity alluvial materials) which influences the direction of groundwater flow around this feature (Figure 3-1). The holes were typically pushed to 14 feet bgs (north of creek) or 19 feet bgs (south of creek) to obtain groundwater samples. Water levels, although not measured in all borings, ranged from 8 to 10.4 feet bgs. At the boring for well 11MW14, north of East Toll Gate Creek, bedrock was interpreted to be about 17 feet bgs, based on the slower rate of pushing at this depth. The water level in this well has taken more than 3 months to stabilize to date; as of September 10, 2010, it was 11.19 feet bgs. This may be partially attributable to mud smearing along the walls of the boring, in addition to low transmissivity of the lithology. At previously installed well off-base well LFW-8, on the south side of East Toll Gate Creek, the water-bearing zone was described as a fine-to medium- to very coarse-grained sand (coarsening downward), which was underlain by claystone at 15.2 feet bgs (Figure 3-2).

Although East Toll Gate Creek is typically dry on-base, off-base, groundwater appears to discharge to East Toll Gate Creek to some extent, based on the base flow (albeit limited) in portions of the creek, and elevations of the creek bed and water in adjacent wells, as shown on Figure 3-2. In this specific off-base area of the creek, the banks are steep, about 8 to 10 feet high, and overgrown with vegetation; and the water is shallow and alternately flows and pools in a narrow channel. Surface water flow is to the northwest. When the initial off-base field investigation was conducted in February 2010, 0.2 to 0.55 foot of water was present at the creek sampling locations, at widths of 2 feet (11CK01 and 11CK02) to 6 feet (11CK03) (Appendix D). At 11CK01, there was no obvious flow; at 11CK02, flow was observed; and at 11CK03, the creek was fairly still. Since that time, water has been continually present in the stretch of creek through the investigation area (as observed though September 2010), although flow is typically not readily apparent, and algae is present in the channel near well LFW-8. Farther downgradient, the creek has been observed to be dry, such as in October 2009.

In the apparent source area of the PCE plume, which is just south of the east end of former Building 1011; bedrock is near the surface, interpreted as 7 feet bgs in well 11MW10, 10 feet bgs in well 11MW09, 11 feet bgs in well 11MW11, and 15 feet bgs at well 11MW05. In June 2010, the potentiometric surface in this area ranged from 24.12 feet bgs in well 11MW05, to 26.93 feet bgs in well 11MW09. The alluvium is unsaturated, and groundwater is primarily in a weathered Denver Formation sandstone. At these wells, the top of the sandstone was observed at approximate depths of 33 to 38.3 feet; it was not described as wet or saturated until depths of 35 to 40 feet. At well 11MW05, the entire water-bearing zone was drilled; it was a thick, fine- to coarse-grained sandstone, beginning about 33 feet bgs (wet at 35 feet bgs), and extending to 52 feet bgs, where it was underlain by a silty claystone. It was similarly present at wells 11MW09, 11MW10, and 11MW11, extending to at least the total depths drilled, which ranged from 43 to 50 feet bgs. As groundwater in this bedrock sandstone migrates downgradient, it appears to discharge into the sand in the alluvial paleochannel, as indicated on Figure 3-2.

3.2.2 North Plume

In the North Plume area, Denver Formation bedrock is about 10.5 feet bgs, as identified in the boring for well 11MW15. However, at well 1011MW07, which was previously installed about 35 feet upgradient (northeast) adjacent to the Building 719 UST, fill material (fine- to medium-grained sand) is interpreted to be present to about 18 feet bgs. As reported in the Triad SI, the UST is a metal cylindrical tank about 4 to 5 feet bgs that appeared to be about the diameter indicated in the historical drawings (9 feet) (the length was indicated as 25 feet), with a capacity of about 10,000 gallons.

In this area, the alluvium is unsaturated, and groundwater is within the Denver Formation bedrock and flows to the southwest (Figure 3-5). At well 1011MW07, below the apparent fill material, weathered bedrock material that appeared to be dry included clayey sand, with lesser amounts of sandy clay and clay. Clayey sandstone was noted as moist from about 30 to 35 feet bgs, where it was underlain by wet, loose, fine- to medium-grained sandstone to about 38 feet bgs, below which dry claystone was present. Similar hydrogeologic conditions were observed upgradient at well 11MW04 (Appendix D). Downgradient of well 1011MW07, the bedrock was primarily claystone and siltstone, with thin dry-moist sandstones. At well 11MW15, alluvial clay and a 1-foot thick sand, were underlain by claystone, siltstone, and sandstone bedrock, which primarily appeared to be dry, except for two, thin moist, or dry-moist, sandstone intervals (21.5 to 24 feet bgs and 28.5 to 31 feet bgs). At downgradient and slightly cross-gradient well 1011MW04, the shallowest moisture was noted in a sandy claystone at 40 feet bgs. At downgradient well 11MW03, a very thin, moist, weathered, clayey sandstone was present from 35.6 to 36.2 feet bgs; above this depth in the Denver Formation, weathered clayey siltstone and a silty sandstone (27.5 to 31.4 feet bgs), which were described as dry or dry-moist, were observed.

The June 2010 potentiometric surface at well 1011MW07 was 23.56 feet bgs. As observed for both wells 1011MW07 and 11MW15, the bedrock in this area does not readily yield water. Under the RI, the groundwater level in well 11MW15 did not stabilize for about 1 month, and the well dewatered, or nearly dewatered, during development and sampling. Similar conditions were observed for well 1011MW07 when it was installed. These conditions indicate the hydraulic conductivity of the zone with contaminated groundwater is low.

3.3 ANALYTICAL RESULTS

Analytical results and summary analytical tables for the investigation are presented in this section. All analytical results are presented in Appendix G. Under the Site 11 RI, 40 groundwater samples (not including field QC samples) from 9 to 20 wells during 3 rounds, and 3 surface water and sediment samples were analyzed for VOCs; and 2 groundwater samples were analyzed for 1,4-dioxane. In addition, 80 groundwater grab samples, and 3 sediment and 3 surface water samples were analyzed for six VOCs. Soil generated during drilling was analyzed for IDW disposal purposes. No other soil samples were collected under the RI, in accordance with the Final Site 11 RI QPP, because no indication of contamination from a soil source was observed in the soil. The IDW data are not discussed in this section; however, they are included in Appendix G.

3.3.1 Groundwater

Table 3-2 presents the VOC and 1,4-dioxane analytical data for the groundwater monitoring wells sampled under the RI, in addition to the previous VOC data for wells 1011MW06 and 1011MW07. Only VOCs detected in one or more of these wells are included on the table. Tables 3-3, 3-4, and 3-5, respectively, present the groundwater grab sampling data from the on-base investigation conducted in June 2009, the off-base groundwater and creek investigation conducted in February 2010, and the off-base investigation conducted in May 2010. In addition, grab groundwater data for a sample collected from the borehole for well 11MW09, and for a sample collected from well 11MW05 (no purging was conducted) are also presented on Table 3-3. Data for these two samples were used for qualitative purposes to support field work determinations.

The following discussion of the groundwater analytical results is subdivided by contamination area/type. The wells installed during the RI included wells 11MW01 through 11MW16; all except three of these wells were installed to investigate the PCE contamination originally identified in well 1011MW06. In addition, the groundwater grab sampling was conducted to investigate the PCE contamination. Wells 11MW03, 11MW04, and 11MW15 were installed to investigate the contamination previously detected in well 1011MW07, referred to as the North Plume area.

3.3.1.1 PCE Plume

In the PCE Plume area, which was investigated based on a detection of PCE above the CBSG in former well 1011MW06, 12 VOCs were detected in the groundwater samples from the monitoring wells. Until the last round of sampling (June-July 2010), only PCE was detected above the regulatory standards applicable to this site. During this last sampling event, bromodichloromethane (BDCM) was detected slightly above the CBSG of 0.56 µg/L, at a concentration of 0.721 µg/L in well 11MW07. In addition, carbon tetrachloride was detected during the July 2009 sampling in one well (11MW11) slightly above the health–based CBSG, which is lower than the drinking water MCL, and not applicable for releases before September 14, 2004. The 11 other VOCs that were detected included TCE; cis-1,2-DCE; chloroform; acetone; benzene; toluene; p-isopropyl toluene; 1,2,4-TMB; m,p-xlenes; o-xylenes; and naphthalene. The latter seven VOCs were only detected in one well each. 1,4-Dioxane was not detected in the single sample collected from a well within the PCE plume (11MW12); therefore, no additional analysis for this compound was conducted in the PCE Plume.

Although BDCM, a trihalomethane, was detected slightly above the CBSG in well 11MW07, it is assumed it (and the other detections of BDCM, in wells 11MW09 and 11MW11) is not from site-related contamination, as most BDCM is formed as a byproduct when chlorine is added to drinking water to kill bacteria (Agency for Toxic Substances and Disease Registry [ATSDR], 1999). Typical levels in drinking water are between 1 and 10 µg/L (ATSDR, 1989). Another trihalomethane, chloroform, was detected at low levels in these and adjacent wells, along the east-southeast side of the site, supporting the conclusion that this is not site-related contamination (Figure 3-6). It may be from leaking water lines, fire hydrants, or potential other

(treated) water releases. Therefore, there is no further discussion of BDCM as related to the investigated PCE plume sources in this report.

PCE was detected in 11 of the 13 wells installed under the RI to determine the extent of contamination previously found in well 1011MW06. PCE concentrations exceeded the CBSG of 5 µg/L in seven of these wells, at concentrations ranging from 9.54 µg/L in well 11MW11, to 157 µg/L in a duplicate sample from well 11MW05 in July 2009. A concentration of 60.2 µg/L was reported in the associated sample from well 11MW05; an explanation for the significantly higher concentration in the duplicate sample was not apparent. PCE was not detected in wells 11MW07 or 11MW08 during any of the three rounds of sampling. Between the sampling rounds, there were no consistent trends in PCE concentration changes, i.e., concentrations increased in some wells and decreased in others.

In the groundwater grab samples collected from the direct-push borings, which were analyzed for six VOCs, three VOCs were detected. These included PCE, TCE, and cis-1,2-DCE. Cis-1,2-DCE was detected only in off-base samples. Only PCE was detected above its CBSG. It was detected in 13 of the 30 on-base direct-push locations that were sampled, at concentrations ranging from 1.2 to 40 µg/L (Table 3-3). In the off-base groundwater grab samples, PCE was detected in samples from 37 of the 47 locations, at concentrations ranging from 0.52 F to 22 µg/L (Tables 3-4 and 3-5). Off-base, PCE concentrations above the CBSG of 5 µg/L were detected only in samples collected north of East Toll Gate Creek (Figure 3-8). TCE was detected in two of the on-base direct-push locations, at concentrations of 1.6 and 2.0 µg/L. TCE was detected in off-base groundwater from 21 of the direct-push locations, at concentrations ranging from 0.63 F to 4.4 µg/L. Cis-1,2-DCE was detected in groundwater samples from three of the off-base locations, at concentrations ranging from 0.62 F to 5.2 µg/L; all three locations were north of East Toll Gate Creek. These data were used to preliminarily identify the location and extent of the PCE plume and appropriate locations to install groundwater monitoring wells, and were also used in the risk assessment.

In addition to the monitoring well data and grab groundwater samples collected from direct-push borings described above, grab groundwater samples were also collected from the borehole for upgradient well 11MW09 and from previously installed well 11MW05 (no purging was performed), and analyzed by the mobile laboratory to provide, respectively, preliminary data on delineation of the upgradient extent of the plume and approximate comparability of grab groundwater data with typical sampling data. As shown on Table 3-3, PCE and the other VOCs were not detected in the grab groundwater sample from the borehole for well 11MW09, indicating the location was in the upgradient plume area, as intended. In the grab groundwater sample from well 11MW05, PCE was detected at a concentration of 200 µg/L, and TCE was detected at a concentration of 3.3 µg/L. As shown on Table 3-2, PCE has been detected in well 11MW05 at concentrations ranging from 34.1 to 157 µg/L, and TCE has been detected at concentrations ranging from 0.876 F to 2.18 µg/L, suggesting data obtained from collecting a grab sample from a monitoring well may be biased high, compared to a sample collected after purging the well.

3.3.1.2 North Plume

In the North Plume area, which was investigated under the RI based on detections of TCE, 1,2-DCA, carbon tetrachloride, and chloroform above the CBSGs in well 1011MW07, 11 VOCs were detected in the groundwater samples. Consistent with previous data for well 1011MW07, the same four VOCs were detected above the CBSGs during the RI sampling. However, previously, the 1,2-DCA concentrations exceeded only the lower health-based CBSG of 0.38 µg/L, compared to the June 2010 exceedance of the drinking water MCL of 5 µg/L, which is generally the applicable cleanup level for releases before September 14, 2004 (Regulation No. 41). The seven other VOCs that were detected in the North Plume area included methylene chloride, 1,2-dichloropropane, acetone, benzene, toluene, p-isopropyl toluene, and naphthalene. 1,4-Dioxane was not detected in the single sample collected from a well near the source of this plume (1011MW07); therefore, no additional analysis for this compound was conducted in this area.

TCE was detected in four wells in the North Plume area, at concentrations ranging from 0.257 F to 65.8 µg/L (Table 3-2). 1,2-DCA was detected in two wells, at concentrations ranging from 1.09 to 6.02 µg/L. Carbon tetrachloride was detected in three wells, at concentrations ranging from 0.626 F to 140 µg/L. Chloroform was detected in all five wells in this area, at concentrations ranging from 0.434 to 93.8 µg/L. The highest concentrations of all four analytes that exceeded CBSGs were detected in well 1011MW07 the last time the well was sampled, and consistently increased between the three events since the well was initially sampled in June 2006. The concentration increases may be associated with the rise in water levels over this period.

In addition to the exceedances of CBSGs in well 1011MW07, CBSGs were also exceeded for groundwater from two other wells in the North Plume area. These included well 11MW15 (1,2-DCA, carbon tetrachloride, and chloroform), and well 11MW04 (carbon tetrachloride and chloroform during the last sampling round). However, of these analytes in these two wells, only chloroform exceeded a CBSG applicable to this site. In wells 11MW04 and 11MW15, in June 2010, chloroform was detected at concentrations of 4.46 and 17.6 µg/L, respectively, compared to the CBSG of 3.5 µg/L. In these two wells, 1,2-DCA and carbon tetrachloride were not detected above the applicable cleanup level of 5 µg/L for releases before September 14, 2004 (Regulation No. 41).

3.3.2 Surface Water

PCE and TCE were detected in all three surface water samples analyzed by the fixed-base laboratory (Table 3-4). No other VOCs were detected. PCE concentrations ranged from 0.304 F µg/L in the downgradient sample (11CK01), to 0.470 F µg/L in the upgradient sample (11CK03). The opposite trend was observed for the TCE concentrations, which ranged from 0.280 F µg/L in the upgradient sample, to 0.380 F µg/L in the downgradient sample. Under the on-site mobile laboratory analysis, no VOCs were detected; however, all reported detections by the fixed-base laboratory were near the method detection limits (MDLs), and the MDLs were slightly higher for the mobile laboratory. As indicated on Table 3-3, none of these

concentrations exceed the applicable surface water quality standards. Therefore, no additional surface water samples were needed to define the extent of contamination.

3.3.3 Sediment

PCE was not detected in the sediment samples; however, both TCE and cis-1,2-DCE were detected in the upgradient sediment sample 11CK03, and TCE was detected in the intermediate sample (11CK02) (Table 3-4). For the sediment samples, although the concentrations differed between the two laboratories, with higher concentrations reported by the mobile laboratory, the detected constituents were the same. TCE was detected at concentrations ranging from 1.15 F micrograms per kilogram (µg/kg) in 11CK02 (2.1 F µg/kg by the mobile laboratory), to 10 µg/kg in 11CK03 (3.63 F µg/kg by the fixed-based laboratory). In sediment sample 11CK03, cis-1,2-DCE was detected at concentrations of 2.91 F and 13 µg/kg. As indicated on Table 3-4, none of these concentrations exceed the CSEVs or EPA RSLs. Therefore, no additional sediment samples were needed to define the extent of contamination.

3.4 ASSESSMENT OF RESULTS

This section presents a summary of the data quality assessment and the nature and extent of contamination at Site 11.

3.4.1 Data Quality Assessment

The data quality indicators of precision, accuracy, representativeness, and completeness were used to determine the overall acceptability and usability of the analytical results for the Site 11 RI project decisions. In general, the majority of the analytical data met all acceptance criteria, and all results are considered usable. The data qualifiers listed in the analytical tables presented in this section and data review reports in Appendix G are considered the final determination of data quality and usability for the Site 11 sample results. Appendix G presents the assessment in detail.

3.4.2 Nature and Extent of Contamination

The nature and extent of contamination at Site 11 is described below for the two distinct plume areas: the PCE Plume, emanating from the source area south of the east end of former Building 1011 and extending off-base; and the smaller North Plume, which originates in the Building 719 UST area and is characterized by other chlorinated solvents. Under the RI, groundwater samples were only analyzed for VOCs, including a separate analysis for 1,4-dioxane. During the previous Triad SI, samples were analyzed for additional analyte suites; based on those data, analyses for groundwater under the RI were limited to VOCs.

No soil samples were collected under the Site 11 RI; at the locations where the RI wells were installed, there was no indication of contaminated soil associated with a soil source. The source of the PCE Plume area appears to be at an asphalt covered area (Appendix D). Similarly, the source of the North Plume area was likely within a gravel-covered landscaped area or asphalt covered area; although the boring for well 1011MW07 was within this landscaped area, an

asphalt layer was observed about 2 feet bgs in the boring (Appendix D). The previous and RI well boring data for these two areas indicate there are not significant residual sources of contaminants in the soil.

3.4.2.1 PCE Plume

In the PCE Plume area, PCE was the primary chemical that exceeded CBSGs. It was detected at maximum concentration of 157 µg/L in a duplicate sample in well 11MW05 (60.2 µg/L was detected in the original sample) in July 2009; other PCE detections in this well have ranged from 34.1 to 71.5 µg/L, indicating the high concentration in the duplicate sample may not have been representative. Carbon tetrachloride in one well (11MW11), during one sampling event (July 2009) (0.283 F µg/L), was slightly above the MDL and the lower health-based CBSG of 0.27 µg/L, but not the higher applicable CBSG of 5 µg/L. BDCM, in one well (11MW07) during one sampling event (June 2010), also exceeded a CBSG. However, as described in Section 3.3.1.1, the BDCM is assumed to be associated with chlorinated drinking water. All other VOCs that were detected in the PCE Plume area wells were below CBSGs. These included TCE; cis-1,2-DCE; chloroform; acetone; benzene; toluene; p-isopropyl toluene; 1,2,4-TMB; m,p-xylenes; o-xylene; and naphthalene. As further described in Section 4.2, it is inferred detections of TCE and cis-1,2-DCE may be present from the degradation of PCE.

The PCE Plume emanates near a bermed/curbed, asphalt-paved area south of the east end of former Building 1011 (Appendix D), and migrates to the southwest-west. The highest PCE concentrations were detected in groundwater this area, as described above for well 11MW05. There may have been spills from potential drums or other containers that may have been near or within the curbed area, or, although no historical information has been found, potentially a subsurface drain line or vessel. A specific point source is not known, and no records have been found that indicate what was formerly likely stored or present in this area. However, former Building 1011 was used for numerous activities that could have used these solvents, as indicated by the detections of elevated levels of PCE, and low detections of TCE and cis-1,2-DCE in sump sediment to the northwest near the center of the former building. PCE was commonly used for metal degreasing. TCE and cis-1,2-DCE are solvents (1,2-DCE was a solvent for lacquers, in addition to other products) and both are also degradation products of PCE. No dense nonaqueous phase liquid (DNAPL) is suspected, based on the low PCE concentrations compared to the solubility.

The plume is approximately 140 feet wide at the source area, and about 40 to 80 feet wide in downgradient areas. The length is approximately 1,100 feet, including about 700 feet on base and 400 feet off base. Near the source area, the PCE contamination is in a weathered Denver Formation permeable bedrock sandstone. The sandstone is about 19 feet thick, as measured in well 11MW05, and begins about 33 to 38.3 feet bgs. Although the shallowest saturated sandstone was observed at 35 feet bgs, in June 2010, the stabilized water levels in this area (24 to 27 feet bgs) were above this level and also above the top of the sandstone. As the PCE-contaminated groundwater migrates downgradient to the southwest, it is primarily within saturated basal alluvial sands, and appears to preferentially flow within an alluvial paleochannel that is incised into the bedrock surface approximately parallel to the overall direction of groundwater flow. This transition occurs between well 11MW05 and former well 1011MW06,

where it is inferred the paleochannel cuts through this bedrock zone. In well 1011MW06, the water-bearing interval was a permeable, medium- to coarse-grained, loose sand. Groundwater becomes shallower in the downgradient plume direction; in June 2010, the depth to groundwater was about 18 feet bgs at well 11MW16, 14 feet bgs at well 11MW13, and 9 feet bgs at well 11MW12. The paleochannel was interpreted to extend to a maximum depth of about 35 feet bgs, at well 11MW16, becoming shallower towards the base boundary.

The PCE Plume appears to almost intersect East Toll Gate Creek west of the base boundary, then it trends to the northwest along the north side of the creek. Off base, the highest PCE concentration was 22 µg/L, detected in a grab groundwater sample from 11DP57, about 100 feet west of the base boundary. The interaction of the PCE-contaminated groundwater with the surface water is indicated by the low concentrations of PCE in the surface water and sediment, and in the groundwater samples collected from the south side of the creek. PCE concentrations did not exceed the CBSG in groundwater samples collected from the south side of the creek (or in the surface water samples). The highest PCE concentration south of the creek was 3.1 µg/L (2.8 µg/L in the duplicate sample), detected in 11DP36, which was generally in-line with the trend of the PCE Plume as it exits the base.

3.4.2.2 North Plume

In the North Plume area, four chlorinated solvents, including TCE, 1,2-DCA, carbon tetrachloride, and chloroform, were detected above the CBSGs. The maximum concentrations of these were detected in well 1011MW07, with concentrations of TCE (65.8 µg/L), chloroform (93.8 µg/L), and carbon tetrachloride (140 µg/L), that ranged up to 13, 27, and 28 times, respectively, their CBSGs. The highest detection of 1,2-DCA (6.02 µg/L) slightly exceeded the CBSG of 5 µg/L which is the MCL. The highest concentrations were detected in June 2010, which may be attributable to the rise in water levels since the 2006 Triad SI. All other VOCs that were detected in the groundwater in this area were below CBSGs. These included methylene chloride; 1,2-dichloropropane; acetone; benzene; toluene; p-isopropyl toluene; and naphthalene. The low levels of benzene and the other hydrocarbons in the groundwater may be associated with the gasoline UST in this area.

The extent of chloroform above its CBSG of 3.5 µg/L is greater than the other three solvents, as it was detected above its CBSG in three wells. As shown on Figure 3-9, the interpreted chloroform plume is about 240 feet long and 80 feet wide, and does not extend past the base boundary. The extents of TCE and carbon tetrachloride are similar to each other (Figures 3-10 and 3-11); they were each detected in one well (1011MW07) above their respective CBSGs, as also was 1,2-DCA. The TCE and carbon tetrachloride plumes are interpreted to be about 75 feet long, with a width of about 50 feet. The lateral delineation in the central plume area is interpreted based on the presence of permeable fill material at the UST location. Chloroform has the highest water solubility of these four analytes, indicating why it may be the most widespread.

The groundwater contamination in the North Plume area is within weathered Denver Formation bedrock. At well 1011MW07, the bedrock underlies fill material that extends to a depth of about 18 feet bgs. The interval screened in this well, from 25 to 40 feet bgs, included

weathered bedrock material; from about 30 to 35 feet bgs, it was described as a moist, platy, clayey sandstone. This material was underlain by the primary water-bearing zone: a 3-foot-thick wet, loose, fine- to medium-grained sand. The sand was underlain by dry claystone at about 38 feet bgs. In the upgradient and downgradient wells, no wet zones were observed in the alluvium or the bedrock. These wells were screened to intercept potential groundwater from the shallowest, dry-moist or moist intervals, which were thin and included claystone, siltstone, and minor amounts of sandstone, typically clayey or silty. Of these wells, the deepest well screen was in 1011MW04, from 45 to 60 feet bgs.

Groundwater levels in the central North Plume area were about 24 to 25 feet bgs in June 2010, about 18 feet bgs in the upgradient area adjacent to Building 1011 (well 11MW04), and 21 feet bgs downgradient at the base boundary (well 11MW03). As described in Section 3.2.2, there is not a consistent/continuous or identifiable (except in well 1011MW07) water-bearing zone, and the bedrock in this area does not readily yield water. This is also indicated by the steepness of the potentiometric surface contours, which show groundwater flow is to the southwest. These conditions indicate the hydraulic conductivity of the zone with contaminated groundwater is low, which has limited the migration of contamination.

The source of the plume appears to be within or near the north edge of the gravel landscaped area where well 1011MW07 is located. The VOCs are likely chemicals associated with vehicle repair or other similar activities in former Building 1011. All of the VOCs detected at elevated concentrations are cleaning and degreasing solvents. In addition, chloroform may be present as a degradation product of carbon tetrachloride (which then also degrades to methylene chloride). However, no degradation productions of TCE were detected. 1,2-DCA was also used in some paint, varnish, and finish removers. Although 1,2-DCA was also used as a scavenging agent in leaded gasoline to prevent build-up of lead inside fuel-line and motor components, because no other elevated levels of gasoline constituents were present, this source is less likely.

The release mechanism for these contaminants is uncertain. With the exception of the gravel landscaped area where well 1011MW07 is located, the ground surface between this well and Building 1011, about 90 feet, is paved with asphalt. Asphalt was also observed about 2 feet bgs in well 101MW07. Solvents may have been released to the ground by spills, as there are no known utility lines or drains from the auto repair shop. It is unlikely the solvents were stored in the UST; it was installed in 1949 to supply fuel for the PW Service Station, and likely taken out of service in the 1970s or 1980s. However, the fill material in the landscaped UST area would have provided a favorable vertical pathway for migration of contaminants. As described in the Triad SI Report, soil contamination, based on staining, odor, and elevated PID readings, was observed from about 12 to 20 feet bgs while drilling well 1011MW07; however, the TPH and BTEX concentrations in soil were below the CDLE OPS RBSLs and other regulatory levels. Although the laboratory did not specifically analyze the soil samples for other VOCs, such as chlorinated solvents (because it was expected that only BTEX compounds would be present), Versar's review of the raw analytical data indicates these additional constituents did not appear to be present in the soil.

4.0 CONTAMINANT FATE AND TRANSPORT

This section presents the potential routes of migration of contamination, describes the contaminant persistence based on the available data, and discusses the factors affecting contaminant migration at Site 11.

4.1 POTENTIAL MIGRATION PATHWAYS

The chlorinated solvents at Site 11 exist primarily as a dissolved phase in groundwater. To date, a significant vapor phase in unsaturated soil has not been observed, based on typically low or negligible PID readings for soil screened during drilling; however, information in the source areas is limited to the well boring locations. The highest PID headspace reading (261 ppm) was measured during the Triad SI, for soil at a depth of about 15 feet bgs at well 1011MW07, which is near the source of the North Plume contamination. Contaminated surface soil is not present, as the source areas are primarily covered by asphalt/pavement or, at the North Plume area, landscaping materials. Contaminated subsurface soil may exist or have previously existed in the source areas; leaks or spills of VOCs to the unsaturated soil in these areas have migrated to the groundwater as indicated by the groundwater contamination. Based on the low levels or apparent absence of soil contamination in the well borings, including in the source area of the North Plume (well 1011MW07), and in the source area of the PCE Plume (well 11MW05, and wells 11MW10 and 11MW11, which are about 60 feet away from well 11MW05), there are no significant residual sources of the VOCs in the unsaturated soil. Therefore, additional downward leaching of contaminants in soil to groundwater is expected to be an insignificant migration pathway. The asphalt cover also may limit the potential for upper movement to the vadose zone and atmosphere.

Therefore, the primary migration pathways for the VOCs detected in groundwater include horizontal and vertical transport of dissolved VOCs in groundwater to downgradient locations, lower water-bearing zones, and surface water and sediment. In addition, there is the potential for off-gassing of VOCs from groundwater to the vadose zone, and vertical and/or horizontal movement of VOCs through the vadose zone and into the atmosphere or overlying potential structures. These pathways, and factors impacting them are discussed in Sections 4.2 and 4.3.

4.2 CONTAMINANT PERSISTENCE

Natural attenuation refers to naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media (ITRC, 1999). These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants. The evaluation of natural attenuation is typically based on a lines of evidence approach, including: (1) documented reduction of contaminant mass at the site; (2) the presence and distribution of geochemical and biochemical indicators of natural attenuation; and (3) direct microbiological evidence. Because of the limited ground monitoring to date at Site 11, reductions of contaminant mass at the site can not be assessed based on historical trends in contaminant concentrations and distribution. Geochemical, biochemical, and microbiological data were not collected specifically under the RI for a natural

attenuation study; however, analytical and field data that were obtained are evaluated in this section to give a preliminary indication of the persistence of the chlorinated solvents in groundwater at Site 11.

Many biological pathways have been identified and described that transform or degrade chlorinated solvents. The most effective biological pathway for the chlorinated solvents detected in Site 11 groundwater is reductive dechlorination. The degradation pathways for PCE and carbon tetrachloride through reductive dechlorination are provided below

PCE → TCE → DCE (primarily cis-1,2) → vinyl chloride → ethene

Carbon tetrachloride → chloroform → methylene chloride → chloromethane → methane

One indication that biodegradation may be taking place *in-situ* involves the presence, concentration, and distribution of the parent compound and daughter products. For example, if TCE is the parent compound, an increase in concentration of cis-1,2-DCE in groundwater (a daughter product of TCE), along with a decrease in TCE concentrations can be used as an indicator that biodegradation is occurring. Parent compounds (PCE and TCE) can occur from co-disposal or for TCE from degradation. However, cis-1,2-DCE, vinyl chloride, and ethene are indicative of biological activity; if all three are present, the biodegradation pathway is going to completion.

Reductive dechlorination may not be possible where groundwater conditions are not conducive for these biological reactions to occur. Highly aerobic aquifers are very poor candidates for reductive dechlorination of chlorinated solvents. At many sites, the dechlorination process can only proceed up to production of cis-1,2-DCE. Of the field parameters obtained during the RI groundwater sampling, DO, ORP (redox potential), pH, and temperature can be used to indicate the potential for natural attenuation to occur. However, the ORP and DO measurements obtained for Site 11 may not be very accurate, because the water was briefly exposed to air, as a pump attached to a flow-through cell was not used. DO is an indicator of aerobic environments, with DO concentrations less than 1 mg/L indicative of anaerobic conditions, and DO concentrations above 1 mg/L indicative of aerobic conditions. ORP is also used to indicate aerobic (0 to 500 millivolts [mV]) or anaerobic (-500 to 0 mV) environments. Temperature and pH indicate whether the environment is suitable to support microbial species activity. The lower limit for microbial activity to occur is 5°C, and microorganisms capable of degrading VOCs tolerate pH values above 5 and less than 9.

4.2.1 PCE Plume

In general, there did not appear to be a significant reduction in mass until the PCE Plume reached the base boundary (Figure 4-1). In this area, the reduction may be because of the apparent less permeable lithology (Figures 3-2 and 3-4); the interaction of the groundwater with the surface water, including volatilization and oxygenation; and the organic matter associated with East Toll Gate Creek, which is heavily vegetated in this area (Appendix D). For example, in the off-base groundwater grab samples collected south of the creek, PCE and TCE were detected at similar concentrations (Table 3-4). This trend also appeared to be developing at the downgradient end of the plume (Figure 3-8). As additional indication of the degradation, in the

sediment sample collected near where the plume exits the base, PCE was not detected, and TCE and cis-1,2-DCE were both detected at similar concentrations. No trans-1,2-DCE or vinyl chloride were detected in any of the samples. Analyses for ethene were not performed. The conditions in the creek area are similar to those intended when wetlands are constructed to treat groundwater. Degradation may occur through root activity, microorganisms, and decaying organic matter that is a carbon source, and plants may also uptake the contaminants.

For the PCE Plume area, as shown Table 4-1, DO concentrations ranged from 1.06 to 8.75 mg/L. The highest DO concentration measured, for well 11MW14, likely reflects its proximity to the creek and the surface water/groundwater interaction. DO concentrations for the surface water ranged from 9.49 to 10.00 mg/L. ORP concentrations were variable between sampling rounds, and ranged from -17.5 to 407 mV. The DO and ORP measurements indicate generally aerobic conditions. Temperatures ranged from 10.9 to 21.7°C, and pH ranged from 6.16 to 7.44, indicating these conditions are favorable for microbial activity.

4.2.2 North Plume

At the North Plume area, no degradation products of TCE were detected, although if TCE was released with petroleum hydrocarbons or other solvents, some degree of intrinsic biodegradation may have occurred. However, the observed decrease in carbon tetrachloride and increase in daughter product chloroform in a downgradient direction suggests biodegradation through reductive dechlorination is occurring. At well 1011MW07, carbon tetrachloride is detected at a higher concentration than chloroform. At well 11MW15, where concentrations of both solvents are lower, the reverse is apparent, as shown on Figure 4-2. Methylene chloride, the daughter product of chloroform, was detected at low concentrations in both wells 1011MW07 and 11MW15, but not farther downgradient. The biodegradation may occur because of the long residence time of the contaminated groundwater in the clayey bedrock material (in well 11MW15, the water level did not stabilize for 1 month after well installation) and also the potential presence of cometabolites or carbon sources, primarily in the form of petroleum hydrocarbons that may have been released in the UST area, although they have been detected only at low concentrations. In well 1011MW07, 1,2-dichloropropane, acetone, benzene, toluene, and TEPH have been detected. Acetone, benzene, and naphthalene have been detected in well 11MW15. In upgradient well 11MW04, acetone and p-isopropyl toluene were detected.

For the North Plume area, as shown Table 4-2, DO concentrations ranged from 1.42 to 7.53 mg/L (both occurred in the same well - 11MW03 - during different sampling events). ORP concentrations ranged from 80 to 240 mV. These DO and ORP measurements indicate aerobic conditions. Temperatures ranged from 12.24 to 15.5°C, and pH ranged from 6.69 to 8.18, indicating these conditions are favorable for microbial activity.

4.3 CONTAMINANT MIGRATION

Data collected during the RI indicate the primary route of migration is through horizontal migration of VOCs dissolved in groundwater. The boundaries and preferential pathways for migration of groundwater are well defined, particularly in the areas of PCE contamination where the direct-push work was conducted. The preferential flow paths are inferred from the

groundwater contaminant distribution and potentiometric surface, and generally follow the natural topography; in many areas of Site 11, this topography has been altered. Migration of PCE to deeper water bearing zones does not appear to be a migration pathway of concern; contamination in the source area is in a weathered bedrock sandstone, and migrates downgradient in and near the bottom of the saturated alluvium in an alluvial paleochannel. At the North Plume area, the contaminants have remained close to the source in bedrock, and vertical and horizontal migration is limited due to the thin, discontinuous water-bearing zones with apparent low hydraulic conductivity. The most widespread contaminant in the North Plume area is chloroform, potentially because it has the highest water solubility of the solvents of concern in this area.

The contaminants in groundwater at the North Plume area have not migrated off base at levels above the CBSGs, and the assessment of contaminant persistence described in Section 4.2 indicates it will likely be similarly limited in the future. In contrast, to the south, PCE has migrated off base above the CBSG of 5 μg/L in the groundwater, to the southwest to west. The migration of PCE through the site has been primarily controlled by an alluvial paleochannel, and PCE may be sorbed on clayey/organic soil deposited on the channel edges. The PCE-impacted groundwater has discharged to East Toll Gate Creek to a limited extent; however, the concentrations of PCE and its degradation products in the surface water and sediments in East Toll Gate Creek are low compared to the water standards and soil screening levels. Off base, the creek appears to alternately gain and lose water. Based on the presence of degradation products and likelihood for this natural degradation to continue, the groundwater and surface water interaction, and the apparent preferential contaminant migration pathway, PCE is not likely to migrate across (south of) the creek at high concentrations in the future. The Basewide EBS reported there are no domestic or municipal drinking water wells within at least 1 mile of Site 11 (AFCEE, 2000). For the Site 11 RI, Versar obtained off-base well location and information from the on-line Colorado Division of Water Resources AQUAMAP, which confirmed this information. The only off-base wells within or near an approximately 1-mile radius from the site are monitoring holes. Appendix H contains a figure that shows these wells, a listing of the associated information for these wells, and additional well listings farther away. Therefore, existing domestic or municipal drinking water wells are too far away to be impacted by the Site 11 groundwater plumes.

The Site 11 contaminated groundwater does not underlie any buildings on base, and it is not near off-base structures. The closest on-base buildings are about 300 feet upgradient of the plumes; Building 1030 is upgradient of the North Plume, and the LDC is upgradient of the PCE Plume. The area west of the base along East Toll Gate Creek is managed as a natural area by the City of Aurora Parks and Recreation; there are no improvements on the property. The closest structures are the Foxdale Condominiums, which are off base, cross-gradient from the plume, about 250 feet to the south (at the closest point) (Figure 3-1). The Buckley base housing development is about 0.5 mile north and west of the plume. Soil vapor would be expected to follow the same pathway as the groundwater contamination. Therefore, the existing buildings are too far away to be impacted by vapor from the groundwater plumes.

5.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

5.1 INTRODUCTION

A baseline human health risk assessment (HHRA) was conducted to determine current and future potential risks to human health as a result of contaminants originating from Site 11 at Buckley Air Force Base that were found in groundwater. Additionally, off-base groundwater samples and sediment and surface water samples collected from East Toll Gate Creek were assessed. This risk assessment is based on EPA guidance documents.

This risk assessment will be used to help determine whether remedial action is required for the site by identifying potential hazards and quantifying associated risks from exposures to on-base chemicals of potential concern (COPCs). Site-specific background information for Site 11 is provided in the site assessment portion (Sections 1.0 through 4.0) of this document.

A quantitative ecological risk assessment was not performed for Site 11. There are no exposure pathways to the contaminated groundwater by ecological receptors on base. The Site 11 plumes have not impacted East Toll Gate Creek on base, very low concentrations of the groundwater contaminants were detected in off-base sediment and surface water, and drainage is intermittent, so the creek not expected to provide habitat that supports significant populations.

5.2 SCOPE OF RISK ASSESSMENT

The EPA provides guidance and specific procedures for conducting baseline risk assessments. This guidance is found in EPA's "Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (RAGS)" (EPA, 1989). Supplemental guidance for performing risk assessments is also periodically issued by EPA (e.g., EPA, 2002a, 2004a, 2009). These guidelines, as well as the EPA Regional Screening Table (EPA, 2010a) were the primary sources of guidance used to conduct the human health risk assessment for this site.

As indicated in RAGS, Part A (EPA, 1989), there are four major steps involved in conducting a human health risk assessment: (1) data collection and evaluation, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization. Each step is briefly described below.

Data collection and evaluation involve gathering and evaluating site data relevant to human health and identifying those substances present at the site(s) that should be the focus of the risk assessment process (i.e., COPCs).

An exposure assessment is conducted to estimate the magnitudes of actual and/or potential human exposures, the frequencies and durations of these exposures, and the pathways by which humans may be exposed. In this exposure assessment, reasonable maximum estimates of exposure have been developed for both current and, if applicable, future land-use assumptions. Current exposure estimates are used to determine potential doses based on existing exposure conditions at the site. Future exposure estimates are used to provide decision-makers with an understanding of potential future exposures and quantitative estimates of the likelihood of such

exposures occurring. Conducting an exposure assessment involves analyzing chemical releases; identifying exposed populations; estimating exposure point concentrations for specific pathways, based on both environmental monitoring data and predictive chemical modeling results; and estimating chemical intakes for specific pathways. The results of an exposure assessment are pathway-specific intakes for current and future exposures to individual substances.

A toxicity assessment considers: (1) the types of adverse health effects associated with chemical exposures; (2) the relationships between magnitudes of exposures and potential adverse effects; and (3) related uncertainties such as the weight of evidence of a particular chemical's carcinogenicity in humans. Toxicity assessments have been generally accomplished in two steps. The first step, hazard identification, is the process of determining whether exposure to an agent can cause an increase in the incidence of an adverse health effect (e.g., cancer, birth defects). Hazard identification also involves characterizing the nature and strength of the evidence of causation. The second step, dose-response evaluation, is the process of quantitatively evaluating the toxicity information and characterizing the relationships between the doses of the chemicals administered or received and the incidence of adverse health effects in the exposed population.

Risk characterization summarizes and combines outputs of the exposure and toxicity assessments to characterize baseline risks, both in quantitative expressions and qualitative statements. During risk characterization, exposure estimates are combined with chemical-specific toxicity information to determine whether current or future contaminant levels at or near Site 11 may be of potential concern.

5.3 MEDIA OF POTENTIAL CONCERN

Based on sampling performed by Versar at Site 11, two distinct groundwater plumes have been recognized and characterized for Site 11 and are identified in this report as the PCE Plume and the North Plume. These plumes have different source areas, different locations, and different chemicals and concentrations. The PCE Plume extends from the source area south of the east end of former Building 1011 and continues to the southwest-west off-base. Off-base, west of the base boundary, the PCE Plume appears to almost intersect East Toll Gate Creek, then moves to the northwest along the north side of the creek. Groundwater from the plume contributes to surface water in East Toll Gate Creek, as evidenced by the low concentrations of PCE in the creek surface water and sediment. The source of the North Plume appears to be within or near the north edge of the gravel landscaped area where well 1011MW07 is located. The VOCs are likely chemicals associated with vehicle repair or other similar activities that occurred historically in Building 1011.

To aid in potential future risk management decisions, the following three areas were evaluated in the HHRA: the On-Base PCE Plume, Off-Base PCE Plume (including sediment and surface water from East Toll Gate Creek), and North Plume. Based on the environmental investigations of the Site, the media of potential concern identified for Site 11 include:

- Groundwater collected from the wells from the On-Base PCE Plume
- Groundwater collected from the wells from the Off-Base PCE Plume

- Groundwater collected from the wells from the North Plume
- Sediment collected from East Toll Gate Creek
- Surface water collected from East Toll Gate Creek

These media were considered to pose sufficient potential current or future health risks, and as a result, have been evaluated in the baseline HHRA.

5.4 DATA REDUCTION

Data for the human health risk assessment were collected in phases during the environmental investigation. A detailed description of the sampling phases is presented in Section 2.0 of this document. Analytical data obtained from these media samples were evaluated to identify chemicals of potential concern (i.e., target analyte list [TAL] and target compound list [TCL] chemicals), in accordance with EPA Quality Assurance Program protocols. The analytical results are presented in Section 3.0 of this document.

The limitations and uncertainties associated with the analytical results were evaluated as part of the data reporting requirements of the analytical laboratories. Analytical data-related qualifiers identified by the laboratory as well as information provided for all field and laboratory blank samples were taken into consideration in the evaluation process. Only data considered usable according to the guidelines established by EPA were used in the risk assessment.

This risk assessment addresses site-related chemicals that were considered to pose significant potential threats to human health. These COPCs for Site 11 were selected based on a combination of their intrinsic toxicities and their levels of occurrence on site. EPA Headquarters guidance presented in *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual (Part A)* (EPA, 1989) generally was followed to determine the COPCs. This guidance and the data screening process are summarized as follows:

- If a chemical was not detected in any of the samples of a particular medium because it was reported as a non-detect (indicated by a "U" qualifier in the laboratory data), that chemical was eliminated from consideration for that medium.

- If a chemical was present as a result of blank contamination (indicated by a "B" qualifier) or because it was rejected (indicated by an "R" qualifier), it was eliminated for that medium.

- Data with "J" qualifiers were assumed to be positive identifications for those media. "J" indicated that the numerical value is an estimated concentration (i.e., it is reported below the minimum confident sample quantitation limit, between the MDL and the RL).

- For sample duplicates, the average of the reported concentrations was used for subsequent calculations. If one sample was a non-detect, the detected concentration was assumed for the sample.

5.5 DATA EVALUATION

The chemical concentrations found at a site may vary spatially. Furthermore, receptors may move within an area where COPCs have been detected. Therefore, it is important to estimate the concentration of a COPC in a manner consistent with the location and route of potential human exposure. This estimate of a chemical concentration is known as the exposure point concentration (EPC). The objective of the data evaluation is to summarize the sampling data collected by medium and location for use in the risk assessment. Summary tables were prepared to present a list of the chemicals detected at the site, the frequency of detection, range of detected concentrations, as well as identifying those chemicals selected as COPCs. Groundwater data was evaluated for three areas: 1) On-Base PCE Plume, 2) Off-Base PCE Plume, and 3) North Plume. Additionally, sediment and surface water were evaluated with the Off-base PCE Plume data. Tables 5-1 through 5-5 present this information for collected groundwater, sediment, and surface water samples.

5.5.1 Screening for Chemicals of Potential Concern

Chemicals were compared to the screening levels presented in the EPA Regional Screening Levels for Chemical Contaminants table (tap water) (EPA, 2010a); CDPHE CSEVs (CDPHE, 2007), CBSGs (Regulation 41); and water quality standards for East Toll Gate Creek (Fish Ingestion standards) (CDPHE, 2008, 2009b) to identify COPCs. To ensure that chemicals with additive effects are not prematurely eliminated during screening, screening levels based on non-cancer toxicity data (denoted with an "nc" in the Screening Table) were multiplied by 0.1. In cases where a chemical has both cancer and non-cancer based screening concentrations, the lower of the two values was used for screening to be more protective of human health.

Chemicals that potentially could present a risk to human health were identified as COPCs by using the following criteria:

- If a chemical was not detected in any sample from a specific medium, it was not considered to be a COPC for that medium.

- The maximum concentration for a detected chemical was compared against the corresponding medium-specific screening level. Detected chemicals were retained if the screening concentration was found to be above the lowest screening level. Those detected chemicals that were found to be below the lowest screening value were eliminated from further consideration.

- A chemical with no screening limit (i.e., no toxicity data) and no appropriate surrogate toxicity value was not further evaluated if no appropriate surrogate chemical was available.

No screening limits for sediment have been developed at this time. Therefore, in order to select COPCs for sediment, the maximum detected concentrations in sediment were compared to

residential soil screening values. Surface water sampling results were compared against groundwater and surface water screening levels.

Although the future use of Site 11 and the Off-Base Plume area is expected to remain the same as the current use, future development, such as residential or commercial was evaluated. Since volatile chemicals have been detected in groundwater at the Site, the potential for vapor intrusion into indoor air in future buildings was evaluated. EPA guidance on evaluating vapor intrusion to indoor air pathways identifies those chemicals that are sufficiently volatile to present an indoor air concern. Detected chemicals in groundwater that the exceed the target groundwater concentrations corresponding to target indoor air concentrations indicated by the guidance or were determined to be COPCs for groundwater were evaluated for the vapor intrusion pathway. The target groundwater concentration is based on a target cancer risk of $1x10^{-6}$ or a hazard index (HI) of 0.1 (EPA 2002b).

5.5.2 Identification of Chemicals of Potential Concern

Table 5-1 presents the summary of groundwater data and the selection process of COPCs for groundwater for the On-Base PCE Plume. Tables 5-2 and 5-3 show similar data for groundwater sampling results for the Off-Base PCE Plume and the North Plume, respectively.

COPCs identified for groundwater on the On-Base Plume include: BDCM, carbon tetrachloride, chloroform, naphthalene, PCE, and TCE. For the groundwater samples from the Off-Base PCE Plume, only cis-1,2-DCE, PCE, and TCE were detected. PCE and TCE were the only COPCs identified for groundwater for the Off-Base PCE Plume. COPCs identified for groundwater at the North Plume include carbon tetrachloride, chloroform, 1,2-DCA, naphthalene, and TCE.

Only cis-1,2-DCE and TCE were detected in sediment from East Toll Gate Creek, but neither was determined to be COPCs. Table 5-4 presents the summary of sediment data and the COPC screening. The fixed-base laboratory data for the sediment, rather than the mobile laboratory data, were used for this screening.

Table 5-5 presents the detected analytes, data summaries, and screening process for surface water from East Toll Gate Creek. Only PCE and TCE were detected in surface water samples and one COPC, PCE, was identified for surface water. The fixed-base laboratory data for the surface water, rather than the mobile laboratory data, were used for this screening.

Tables 5-6 through 5-8 present the COPC selection process and results for the vapor intrusion pathway for groundwater in the On-Base PCE Plume, Off-Base PCE Plume, and the North Plume, respectively. The chemicals detected in groundwater were selected as COPCs based on whether they were determined to be sufficiently volatile to enter into indoor air and present a potential health threat. The screening used Table 2c, "Question 4, Generic Screening Level and Summary Sheet – Risk $1x10^{-6}$" found in EPA's *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathways from Groundwater and Soils (Subsurface Vapor Intrusion)* (EPA, 2002b).

Table 5-9 summarizes all the COPCs identified for the sampled media at Site 11, including groundwater associated with the On-Base PCE Plume, the Off-Base PCE Plume, and the North Plume; surface water; and sediment.

5.6 EXPOSURE ASSESSMENT

Exposure bridges the gap between a potential hazard (i.e., presence of a toxic chemical) and a risk. Exposures to chemicals may occur via inhalation, ingestion, or by dermal absorption routes. The objectives of an exposure assessment are to: (1) identify populations that may potentially be exposed to COPCs; (2) identify the pathways by which such exposures may occur; and (3) quantify chemical intakes, or potential dose, based on the magnitudes, frequencies, and durations of these potential exposures. The exposure assessment thus provides pathway-specific intakes for current and future exposures to site-related COPCs.

An exposure assessment was conducted to estimate the type, timing, and magnitude of exposures that human receptors may experience due to contact with the COPCs remaining in groundwater, surface water, and sediment. Exposures were evaluated for both current and potential future site conditions. The following subsections address the identification of potentially exposed populations, the identification of pathways of exposure, and the calculations and assumptions used to quantify potential exposures. Table 5-10 presents the potentially exposed populations and the pathways/routes by which they may be exposed for the exposure scenarios evaluated, and Figure 5-1 shows the conceptual site model for this HHRA.

5.6.1 Identification of Potential Exposure Populations

Human receptors potentially at risk from exposure to COPCs were identified based on current and future land uses and potentially exposed population groups that may plausibly be located on the Site or on the off-base area where the PCE Plume has migrated. It is assumed that the area where Site 11 is located will remain in its current state. However, for purposes of conducting a conservative evaluation of the potential risks from the COPCs at the Site, some receptors that are extremely unlikely to be found at the Site, either currently or in the future (i.e., residents), are evaluated. Potential current and future receptors and exposure scenarios identified for Site 11 are described below:

> Current Scenarios: There is no current facility activity at Site 11. The Site 11 contaminated groundwater does not underlie any buildings on base, and it is not near off-base structures. There are no domestic or municipal drinking water wells within at least 1 mile of Site 11 (Section 4.3, Appendix H). The area west of the base along East Toll Gate Creek is managed as a natural area by the City of Aurora Parks and Recreation; there are no improvements on the property. The closest structures are the Foxdale Condominiums, which are off base, cross-gradient from the plume, about 250 feet to the south (at the closest point) (Figure 1-3). With a residential area in the vicinity of East Toll Gate Creek, it may be possible for visitors such as youths to spend time at the site and come into contact with surface water. In this specific off-base area of the creek, the banks are steep, about 8 to 10 feet high, and overgrown with vegetation. Also, the water is shallow and alternately flows and pools in a narrow channel. Therefore, direct contact

with the surface water would not likely be frequent due to the difficult terrain surrounding East Toll Gate Creek and low volume of the creek.

Future Scenarios: Future uses of the Site are expected to remain the same as they currently are. Although the potential for building construction over the groundwater plumes is considered unlikely, is assumed to take place on the Site. Because of the depth to groundwater at the Site, construction workers would potentially be exposed indirectly to groundwater during excavation and construction activities. Although the current use of the Site is not likely to change, residential development at the site was considered as a potential future scenario for risk assessment purposes. Additionally, commercial development of the Site was evaluated as a potential future exposure scenario. Hypothetical future residents may be exposed to groundwater if the aquifer were developed as a potential drinking water source. Also, chemicals volatilizing from groundwater beneath a structure could migrate to the surface and through the building slab, impacting indoor air.

Off-base, the area west of the base along East Toll Gate Creek is managed as a natural area by the City of Aurora Parks and Recreation and is expected to be maintained as such in the future. If periodic maintenance of the natural area is performed in the future, the worker may come into direct contact with COPCs found in the surface water. Youth visitors to the site may also potentially come into contact with surface water. Although highly unlikely, future residential development off-base in the area of the PCE plume was considered as a potential future scenario for risk assessment purposes. Evaluating residential receptors, which include adults and children, presents an upper-bound risk for the chemicals from Site 11 in the area of the PCE plume. As a result, future residents could be exposed to groundwater, if the aquifer was developed as a potential drinking water source. Similarly, no commercial/industrial development is expected in the off-base area being evaluated in the HHRA, but is assessed for risk management purposes. Hypothetical development of the off-base area would result in construction workers or utility workers coming into contact with groundwater while conducting excavation.

Designation of an exposure pathway as "complete" indicates that human exposure is possible, but does not necessarily mean that exposure will occur, or that exposure will occur at the levels estimated in this report. Potential sources of COPCs include soil, groundwater, sediment, surface water, and aquatic organisms. Chemical fate and transport processes were used to define the potential migration pathways at Site 11 and included: (1) transfer of COPCs between environmental media, such as soil and air; and (2) transport of COPCs through movement of an environmental medium by natural advective and dispersive processes, such as air dispersion.

Based on the above information, the following exposure pathways were considered for the human health risk assessment of Site 11:

Groundwater (On-Base PCE Plume and North Plume):

- Future inhalation of volatilized COPCs in trench air from groundwater by construction workers
- Future ingestion of COPCs in groundwater used as drinking water by residents (adult and child)
- Future dermal absorption of water by adult residents during showering
- Future dermal absorption of water by child residents during bathing
- Future ingestion of COPCs in groundwater by commercial workers
- Future inhalation of COPCs in indoor air that have volatilized from groundwater by adult and child residents and commercial workers

Groundwater (Off-Base PCE Plume):

- Future incidental ingestion and dermal absorption of COPCs in groundwater by construction workers during excavation/construction activities
- Future inhalation of COPCs that have volatilized from groundwater during excavation activities by construction workers
- Future ingestion of COPCs in groundwater used as drinking water by residents (adult and child)
- Future dermal absorption of water by adult residents during showering
- Future dermal absorption of water by child residents during bathing
- Future inhalation of COPCs in indoor air that have volatilized from groundwater by adult and child residents

Surface Water:

- Current/future incidental ingestion and dermal absorption of surface water by visitors
- Future incidental ingestion and dermal absorption of surface water by maintenance workers

5.7 DETERMINATION OF REPRESENTATIVE CHEMICAL CONCENTRATIONS

EPCs for the COPCs were calculated based on chemical measurements from groundwater and surface water impacted by Site 11 activities.

5.7.1 Groundwater and Surface Water EPCs

EPCs for each COPC were assessed assuming the maximum detected concentration. Table 5-20 presents the EPCs for groundwater associated with COPCs identified for the On-Base PCE Plume, Off-Base PCE Plume, and North Plume. Table 5-20 also present the EPCs for COPCs identified in East Toll Gate Creek surface water.

5.7.2 Indoor Air EPCs

There are no buildings currently on site. Residents and commercial workers may potentially be exposed to concentrations of volatilized chemicals from the surrounding substrate that enter "hypothetical future-use buildings" they spend time in. Chemicals may volatilize from soil and/or groundwater. EPCs for COPCs in indoor air were calculated for groundwater associated with the On-Base PCE Plume, the Off-Base PCE Plume, and the North Plume. Contaminant concentrations in indoor air were estimated using Johnson and Ettinger's (1991) analytical solution for convective and diffusive transport of vapor-phase contaminants. The conceptual model is based on the transport of soil gas into the interior of a hypothetical structure through cracks in the foundation. The driving force is a pressure gradient between the soil and the lower portion of the interior of the structure, which is caused by the rising of warm air inside the structure. The EPA-developed spreadsheet used to calculate the EPCs was GW-ADV, the advanced model for assessing vapor intrusion from contaminated groundwater (EPA, 2004b).

Because there are no buildings on site, default assumptions for hypothetical building parameters provided in the models were assumed. Site-specific soil parameters were assumed in the model. The depth to the water table was based on the depths to groundwater measured in each of the areas. The assumed vapor intrusion model input parameters for each area are shown in Tables 5-11 through 5-13. Model vapor concentrations calculated for groundwater intrusion are summarized in Tables 5-14 through 5-16. The indoor air concentration, $C_{building}$, found on the "INTERCALCS" sheet of the models, is based on a unit concentration. Therefore, the calculated result for $C_{building}$ has to be multiplied by the respective COPC concentration in soil or groundwater to obtain the indoor air concentration.

5.7.3 EPCs for Air in a Construction/Utility Trench

In order to estimate the exposure of construction workers to volatiles from groundwater in a construction/utility trench, a combination of a vadose zone model to estimate volatilization of gases from contaminated groundwater into a trench and a box model to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere was used. This approach has been recommended by Virginia Department of Environmental Quality (VDEQ) in its Voluntary Remediation Program (VRP) Risk Assessment Guidance (VDEQ, 2008). VDEQ has developed spreadsheets to calculate the air concentrations in a trench from chemicals

volatilized from groundwater. The detailed elements of the model used to calculate the concentration of volatiles in a construction trench are found in Section 3.2.2, "Exposure of Workers to Volatiles in a Construction/Utility Trench" of the VRP guidance document (VDEQ, 2008).

If the depth to groundwater at a site is more than 15 feet, VDEQ assumes that a construction/utility worker would indirectly encounter groundwater when digging an excavation or a trench. The worker would not have direct exposure to the groundwater, but would be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater below the trench.

When the depth to groundwater at a site is less than 15 feet, a construction/utility worker is assumed to encounter groundwater when digging an excavation or a trench. In this case, the worker would then have direct exposure to the groundwater and would also be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater pooling at the bottom of the trench.

VRP Tables 3.7, "Groundwater greater than 15 feet deep", and 3.8, "Groundwater less than 15 feet deep" (https://www.deq.virginia.gov/vrprisk/tables.html), were used to calculate the trench air concentration. For modeling purposes, the VDEQ spreadsheet assumes that the trench is 3 feet wide by 8 feet long. The calculated chemical concentrations in trench air are shown in Tables 5-17 through 5-19.

5.8 ESTIMATION OF EXPOSURE INTAKE

Chemical exposure is a result of the intake or uptake of a chemical from the environment. This section of the report describes the methods used to quantitatively evaluate potential receptor exposures associated with Site 11. The equations, as well as the parameters, that were used to estimate chronic daily intake (CDI) of the COPCs for each receptor are presented. Each exposure scenario described in this section of the report is based on the premise that the extent of exposure to a chemical in an environmental medium is proportional to the concentration of the chemical in the medium, rate of contact with the medium, and the duration of exposure. Reasonable Maximum Exposures (RMEs) were estimated to ensure that exposures represent the highest level of exposure that may reasonably occur, but are not necessarily the worst level of exposure (EPA 1989, 2002a, 2004a).

Exposure dose is related to the magnitude, frequency, and duration of exposure. These parameters are calculated by combining the EPC and the various exposure parameters. Two types of doses are calculated representing cancer risk and non-cancer effects. The lifetime average daily dose (LADD) is averaged over a 70-year lifetime and is an estimate of cancer risk. The average daily dose (ADD) is proportional to the actual exposure duration for a receptor and represents non-cancer health effects.

The exposure models and the specific parameter values used to estimate intake for each plausible receptor are summarized in Tables 5-21 to 5-26. Specific values and assumptions used in estimating exposures were selected based on EPA guidance and documents (EPA 1989,

1997a, 2002a, 2004a) and professional judgment. The groups of receptors that may be exposed to COPCs include: (1) future commercial workers, (2) future construction/utility workers, (3) future residents, (4) future maintenance workers, and (6) current/future site visitors. The exposure scenarios and parameters used in estimating intake of COPCs and risks for each receptor group are described in the following sections.

5.8.1 Future Commercial Workers

Although commercial development is not anticipated, hypothetical future commercial workers were evaluated. Although the groundwater found on-base is not used as a source of drinking water, the commercial worker was assumed to drink the groundwater (Table 5-21). Additionally, volatiles from groundwater below the hypothetical future building may enter the work environment by vapor intrusion and could subsequently be inhaled by commercial workers (Table 5-23).

The commercial worker is assumed to be exposed for 250 days/year (exposure frequency [EF]) over a 25-year exposure duration (ED) (EPA, 2002a). The carcinogenic averaging time (ATc) is 25,550 days (i.e., 70 years x 365 days/year), while the non-carcinogenic averaging time (ATnc) is 9,125 days. The commercial worker body weight (BW) is 70 kilograms (kg) (EPA, 2002a). The worker is assumed to ingest 2 liters (L) of water per day (EPA, 2002a).

5.8.2 Future Construction/Utility Workers

Although not anticipated, future on-base development requiring construction or utility work at the Site 11 was evaluated. During construction activities the worker could encounter groundwater when digging an excavation or a trench. On base, the construction/utility worker is not likely to come into direct contact with groundwater, but may be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater below the bottom of the trench. However, off-base where groundwater is found at shallower depths, a construction worker may have direct exposure with the groundwater and may also be exposed to contaminants in the air inside the trench that would result from volatilization from the groundwater pooling at the bottom of the trench. Potential exposure pathways to COPCs in groundwater include incidental ingestion of groundwater (Table 5-21), dermal absorption of COPCs in groundwater (Table 5-22), and inhalation of volatilized COPCs from the groundwater in the trench (Table 5-24).

A future construction worker was assumed to be a 70-kg adult who works 8 hours per day, 5 days per week. Based on recommended values (EPA, 2002a), it was assumed that construction work may occur for an entire year and consist of 120 working days (5 days a week for 6 months). Clothing was assumed to provide partial protection to construction workers from dermal exposure to groundwater. A skin surface area (SA) of 3,300 square centimeters (cm^2)was assumed to contact groundwater (EPA, 2002a). The ATc assumed was 25,550 days (i.e., 70 years x 365 days/year) and the ATnc was 183 days/year (EPA, 1989).

For contact with groundwater, the absorbed dose per event (DA_{event}) was calculated following the approach in EPA's dermal risk assessment guidance (EPA, 2004a). Table 5-22

shows the equations and parameters associated with the calculations. An event duration (t_{event}) of 2 hours/event with an event frequency (EV) of 1 event/day was assumed. The calculations for DA_{event} are presented in Appendix I, Table I-2.

5.8.3 Hypothetical Future Residents

Future residential development of the Site and the off-base area where the PCE plume extends is not very likely; however, for risk assessment purposes, to obtain an upper-bound estimate of risk, the receptor group was evaluated. Although not highly likely, it was assumed that the groundwater found at and downgradient of Site 11 is used as a source of drinking water for the household. As a result, hypothetical residents would be expected to ingest groundwater (Table 5-21) and have dermal contact while showering (adult) (Table 5-22) and bathing (child) (Table 5-22). Vapor intrusion of COPCs from groundwater could also result in inhalation exposure to the adult and child resident (Table 5-23).

The residential receptors were assumed to be exposed for 350 days/year (EF) over a 24-year ED for adults and 6 years for children (EPA, 2002). The ATc is 25,550 days (i.e., 70 years x 365 days/year), while the ATnc is 2,190 days and 8,760 days for children and adults, respectively. The child BW is 15 kg and the adult is 70 kg (EPA, 2002a). The hypothetical residents were assumed to ingest 1 L (child) and 2 L (adult) of water per day (EPA, 2002a.

For contact with groundwater, the absorbed dose per event (DA_{event}) was calculated following the approach in EPA's dermal risk assessment guidance (EPA, 2004a). The SA for adults showering was 18,000 cm^2 and 6,600 cm^2 for children bathing. An event duration (t_{event}) of 1 hour/event for children (EPA, 2004a) and 35 minutes/event or 0.58 hour/ event (EPA, 2004a) for adults with an EV of 1 event/day were assumed. The calculations for DA_{event} are presented in Appendix I, Tables I-1, I-2, and I-4.

5.8.4 Current/Future Maintenance Workers

Current and future maintenance workers could be exposed to COPCs in surface water while performing routine activities near East Toll Gate Creek, such as periodic maintenance and grounds keeping. The maintenance worker was assumed to come into contact with surface water via incidental ingestion and dermal contact. Exposure parameters and equations used to calculate the daily intakes for the maintenance workers are shown in Tables 5-25 and 5-26.

The hypothetical maintenance worker was assumed to be an adult with a BW of 70 kg (EPA, 2002a) who is at the site 12 days a year (1 day per month). ED was assumed to be 25 years. The ATc was 25,550 days (i.e., 70 years x 365 days/year) (EPA, 2002a). The ATnc was 9,125 days.

Maintenance workers are expected to come into dermal contact with surface water, however, it was assumed that clothing would provide partial protection. Surface water contact was assumed to occur on a skin SA of 3,300 cm^2 (EPA, 2002a). The absorbed dose per event (DA_{event}) was calculated following the approach in EPA's dermal risk assessment guidance

(EPA, 2004a). An event duration (t_{event}) of 2 hours/event (EPA, 2004a) for adults with an EV of 1 event/day. The calculations for DA_{event} are presented in Appendix I, Table I-3.

5.8.5 Current/Future Visitors

For this HHRA, a visitor was conservatively assumed to be a youth between the ages of 12 and 17 years with an average body weight of 60 kg (50th percentile body weight) (EPA, 1997a). Based on professional judgment, the youth visitors were assumed to spend 24 days a year at the site with an ED of 6 years. The ATc is 25,550 days (i.e., 70 years x 365 days/year), while the ATnc is 2,190 days.

Visitors could be exposed to surface water while spending time along East Toll Gate Creek. They are assumed to incidentally ingest surface water (Table 5-25) and come into dermal contact with surface water (Table 5-26) while wading or playing in the water. The skin surface area of 6,300 cm^2 (representing feet, lower legs, hands, and head) (EPA, 2004a) is assumed for the youth for contact with surface water (EPA, 2004a). An incidental ingestion rate for surface water (IR-SW) of 0.05 L/hour was assumed, with exposures lasting 2 hours per day. The absorbed dose per event (DA_{event}) was calculated following the approach in EPA's dermal risk assessment guidance (EPA, 2004a). An event duration (t_{event}) of 1 hour/event with an EV of 1 event/day. The calculations for DA_{event} are presented in Appendix I, Table I-3.

5.9 HUMAN TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to evaluate available evidence regarding the potential for site-related chemicals to cause adverse effects in exposed populations and to provide estimates of the relationship between the extent of exposure and the increased likelihood of adverse effects, i.e., dose-response relationships. The results of the toxicity assessment are integrated with the exposure assessment to estimate the cancer risks and noncarcinogenic health impacts in the risk characterization section.

Toxicity values were obtained from several primary sources, according to the following order of priority: (1) a listing of carcinogenic slope factors (SFs) and references doses (RfDs) developed by the EPA found in the Integrated Risk Information System (IRIS) (EPA, 2010b), (2) toxicity values listed in the EPA's Regional Screening Table (EPA, 2010a), and (3) the annual version of the U.S. EPA's Health Effects Assessment Summary Tables (HEAST) (EPA 1997b). Other sources are noted where appropriate.

5.9.1 Carcinogenic Slope Factors

The EPA's Carcinogen Assessment Group (CAG) have developed SFs (expressed in units of $(mg/kg/day)^{-1}$) for estimating the individual upperbound excess lifetime cancer risks associated with various levels of lifetime exposure to potential human carcinogens.

For carcinogens, the EPA assumes no threshold or a zero-threshold. This means there is some finite risk no matter how small the dose. The SF for a given chemical carcinogen is a plausible upper-bound estimate of the probability of a response per unit intake of that chemical

over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. A second important factor for carcinogens is the EPA weight-of-evidence classification, whereby, carcinogens are grouped according to the quality and quantity of data that indicate that an agent is a human carcinogen.

Oral and inhalation SFs used in assessing potential carcinogenic health effects at Site 11 are shown in Tables 5-27 and 5-28, respectively.

5.9.2 Noncarcinogenic Reference Doses

An RfD for a substance is the daily intake or dose per unit body weight (mg/kg/day) that is likely to be without appreciable risk to human populations, including sensitive subgroups. The RfD allows for the existence of a threshold dose, that is, a certain minimum intake of substance below which there will be no observable toxic effects based on the metabolic and detoxifying capacities of exposed individuals. EPA considers exposures to most noncarcinogens to have thresholds below which no toxic effects will occur. The reference concentration (RfC) is an estimate of a daily inhalation exposure to a chemical that is likely to be without an appreciable risk of deleterious effects.

Oral RfDs and inhalation RfCs and RfDs are shown in Tables 5-30 and 5-31, respectively. These tables also provide information on the health effect of concern or critical effect for each chemical.

5.9.3 Chemicals for Which EPA Has Not Developed Toxicity Values

Surrogate toxicity values were used to assess dermal exposures and used for chemicals without specific toxicity values. Based on EPA guidance (EPA, 1992), oral toxicity values were used to evaluate dermal exposures. This generally is not expected to significantly underestimate the risk or hazard relative to the other routes of exposure. Other toxicity values were determined either by assuming that certain chemical isomers have similar toxic effects or that toxicity values developed for a specific route of exposure can be extrapolated to other routes (i.e., route-to-route extrapolation). Chemicals evaluated with surrogate toxicity values are noted as such.

5.10 HUMAN HEALTH RISK CHARACTERIZATION

Risk characterization integrates the exposure assessment and chemical toxicity information to quantitatively estimate potential health risks due to COPCs. Risk estimates were determined for individual routes of chemical exposure as well as for additive effects. The results of the risk characterization provide a basis for decisions regarding further action at Site 11.

5.10.1 Risk Estimation Procedures

Because of fundamental differences in the calculation of critical toxicity values, the estimates of potential individual excess carcinogenic risks and noncarcinogenic health effects were developed separately.

5.10.1.1 Carcinogenic Risk Probabilities

Risk probabilities can be compared to the generally acceptable risk range specified by the EPA. According to the revised NCP (EPA, 1990), carcinogenic risks from exposures at Superfund sites are considered to be unacceptable at a level greater than $1x10^{-4}$, whereas risks smaller than $1x10^{-6}$ are considered to be of minimal concern. Action may not be necessary in the risk range of 10^{-6} to 10^{-4}. This is supported in the directive "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (EPA, 1991), which indicates action is generally warranted at a site when the cumulative carcinogenic risk for any medium is greater than 10^{-4} or the cumulative noncarcinogenic Hazard Index (HI) exceeds 1. In general, a potential excess individual lifetime cancer risk of $1x10^{-4}$ is used by the EPA as a "point of departure" when determining whether chemical exposures represent a potentially unacceptable level of risk to public health. Altogether, this range of potentially acceptable risks helps put the numerical risk estimates into perspective. CDPHE's target cancer risk is $1x10^{-6}$;

Risk probabilities determined for each carcinogen were also considered to be additive over all exposure pathways so that an overall risk of cancer was estimated for each group of potentially exposed receptors.

5.10.1.2 Noncarcinogenic Hazard Quotients and Hazard Indices

In a manner similar to carcinogens, Hazard Quotient (HQ) values were summed across exposure pathways and for all chemical exposures to develop HI values. A HQ or HI value greater than 1 indicates that an adverse health effect may occur due to a chemical exposure. HQs and HIs are not risk probabilities, but currently are accepted by the EPA as quantitative levels of risk for noncarcinogens or the noncarcinogenic endpoints of carcinogens.

5.10.2 Risk Estimates

The total carcinogenic risks and overall noncarcinogenic HI values were estimated for each receptor of potential concern for exposure associated with COPCs from the On-Base PCE Plume, Off-Base PCE Plume (including off-base surface water from East Toll Gate Creek), and North Plume. Risks are provided for each receptor group, each COPC, and each potentially complete exposure pathway. Each set of risk analyses provides a determination of the contribution (noted as percentages) of each compound to the overall risk estimates. The risk analyses therefore provide an indication of the influence of individual COPC on the overall risk estimates. The risks are presented in Tables 5-32 through 5-47. Detailed calculations are shown in Appendix I, Tables I-5 through I-17.

Risks estimated for each group of receptors at location evaluated are discussed below.

5.10.2.1 Future Commercial Workers

<u>On-Base PCE Plume</u>: Carcinogenic and non-carcinogen risks calculated for hypothetical future commercial workers are summarized in Table 5-32. Carcinogenic risk probabilities are

calculated for future commercial workers located on base in the area of the PCE Plume who potentially would be exposed to COPCs in groundwater associated with Site 11. Table 5-32 shows that the overall cancer risk estimates for future commercial workers is approximately $4.12x10^{-4}$. The on-base risks are mainly due to PCE ($4.11x10^{-4}$), in particular, the ingestion of groundwater ($4.10x10^{-4}$). The estimated total cancer risk is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-5.

Non-carcinogenic HIs are also calculated for future commercial workers potentially exposed to COPCs associated with the On-Base PCE Plume (Table 5-32). HIs for all of the COPCs were determined to be less than 1, with the total HI estimated at approximately 0.221. Since the overall HI was estimated to be less than the target HI of 1.0, the likelihood of future commercial workers experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-5.

North Plume: Carcinogenic and non-carcinogen risks estimated for hypothetical future commercial workers are summarized in Table 5-43. The calculated carcinogenic risk from exposure to COPCs associated with groundwater in the North Plume is $1.06x10^{-4}$. Carbon tetrachloride, chloroform, 1,2-DCA, and TCE each contribute risks higher than $1x10^{-6}$, with the majority of the risk from carbon tetrachloride (65%) and, in particular, from the ingestion of groundwater ($6.85x10^{-5}$ due to carbon tetrachloride). The estimated total cancer risk is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-14.

Non-carcinogenic HIs were also calculated for future commercial workers potentially exposed to COPCs in groundwater from the North Plume at Site 11 (Table 5-43). HIs for all of the COPC were determined to be less than 1.0, with a total HI of 0.878. Since the overall HI was estimated to be less than the target HI of 1.0, the likelihood of future commercial workers experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-14.

5.10.2.2 Future Construction/Utility Workers

On-Base PCE Plume: Carcinogenic risk probabilities are calculated for future construction workers potentially exposed to COPCs in on-base groundwater associated with the PCE Plume. Table 5-33 shows that the total cancer risk for future construction workers is approximately $1.83x10^{-7}$. Because the depth to groundwater at this location is quite deep (~24 feet bgs), the hypothetical construction worker would not likely come into direct contact with groundwater during excavation activities and is exposed only via inhalation of volatilized COPCs that may accumulate in a trench. The risk estimate is below the EPA and CDPHE target risk of $1x10^{-6}$, indicating that action at the site may not be necessary based on this receptor group. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-6.

The non-carcinogenic risk or HI is also calculated for future construction workers potentially exposed to COPCs in on-base groundwater associated with the PCE Plume (Table 5-33). The total HI is 0.0160 which is below the target HI of 1.0. Since the overall HI is estimated to be less than the target HI of 1.0, the likelihood of future construction workers experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-6.

Off-Base PCE Plume: Carcinogenic and non-carcinogen risks calculated for hypothetical future off-base construction workers are summarized in Table 5-38. Carcinogenic risk probabilities are calculated for potential future construction or utility workers that may be exposure to COPCs in groundwater from the PCE Plume. Table 5-38 shows that the overall cancer risk estimates for these workers is approximately 7.82×10^{-7}. The risk estimate is below the EPA and CDPHE target risk of 1×10^{-6}, indicating that action at the site may not be necessary based on this receptor group. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-10.

The non-carcinogenic risk or HI is also calculated for future construction workers potentially exposed to COPCs in off-base groundwater associated with the PCE Plume (Table 5-38). The total HI was 0.0596 which is below the target HI of 1.0. Since the total HI was estimated to be less than the target HI of 1.0, the likelihood of future construction workers experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-10.

North Plume: Carcinogenic risk probabilities are calculated for future construction workers potentially exposed to COPCs in on-base groundwater in the area of the North Plume. Table 5-44 shows that the overall cancer risk estimate for future construction workers is approximately 6.15×10^{-7} for the North Plume. Because the depth to groundwater at this location is quite deep (~24 feet bgs), the hypothetical construction worker would not likely come into direct contact with the groundwater during excavation activities. Potential exposure occurs via inhalation of volatilized COPCs accumulating in trench air. The risk estimate is below the EPA and CDPHE target risk of 1×10^{-6}, indicating that action at the site may not be necessary based on this receptor group. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-15.

The non-carcinogenic risk or HI is also calculated for future construction workers potentially exposed to COPCs in on-base groundwater associated with the North Plume (Table 5-44). The total HI was 0.109 which is below the target HI of 1.0. Since the total HI was estimated to be less than the target HI of 1.0, the likelihood of future construction workers experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-15.

5.10.2.3 Hypothetical Future Adult Residents

On-Base PCE Plume: Carcinogenic risk probabilities were calculated for hypothetical future adult residents who potentially may be exposed to COPCs in on-base groundwater associated with the PCE Plume. Residents are assumed to come into contact with COPCs in groundwater

via ingestion of and dermal contact with groundwater, and inhalation of indoor air impacted by vapor intrusion. Table 5-34 shows that the total cancer risk for future adult residents is approximately 7.12×10^{-4}. A majority of the risk, 7.10×10^{-4} (99.8% of total risk) is due to exposure to PCE. All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest contributor being ingestion of groundwater 5.51×10^{-4}. The estimated total cancer risk is above the 1×10^{-4} EPA and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-7.

Non-carcinogenic risks are also calculated for hypothetical future adult residents potentially exposed to COPCs in on-base groundwater associated with the PCE Plume (Table 5-34). The total HI was 0.404 which is below the target HI of 1.0. Since the overall HI was estimated to be less than the target HI of 1.0, the likelihood of future adult residents experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-7.

Off-Base PCE Plume: Carcinogenic and non-carcinogen risks calculated for hypothetical future off-base adult residents are summarized in Table 5-39. Carcinogenic risk probabilities were calculated for hypothetical off-base residents that may be exposure to COPCs in groundwater from the PCE Plume via ingestion, dermal absorption, and inhalation. Table 5-39 shows that the overall cancer risk estimate for adult residents is approximately 1.51×10^{-4}. The risks are mainly due to PCE (1.49×10^{-4} or 99%). All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest contributor being ingestion of groundwater, 1.12×10^{-4}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-11.

Non-carcinogenic risks are also calculated for hypothetical future adult residents potentially exposed to COPCs in off-base groundwater associated with the PCE Plume (Table 5-39). The total HI was 0.0888 which is below the target HI of 1.0. Since the overall HI was estimated to be less than the target HI of 1.0, the likelihood of future adult residents experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-11.

North Plume: Carcinogenic risk probabilities were calculated for hypothetical future adult residents who potentially may be exposed to COPCs in on-base groundwater associated with the North Plume. Residents are assumed to come into contact with COPCs in groundwater via ingestion, dermal contact, and inhalation of indoor air impacts by vapor intrusion. Table 5-45 shows that the total cancer risk for future hypothetical resident adults is approximately 1.95×10^{-4}. Carbon tetrachloride, chloroform, 1,2-DCA, and TCE each contribute carcinogenic risks higher than 1×10^{-6}, with the majority of the risk from carbon tetrachloride (1.11×10^{-4} or 57%) and, in particular, from the ingestion of carbon tetrachloride in groundwater, 9.21×10^{-5}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-16.

Non-carcinogenic risks are also calculated for hypothetical future adult residents potentially exposed to COPCs in on-base groundwater associated with the North Plume (Table 5-45). The total HI was 1.42 which exceeds the target HI of 1.0. Carbon tetrachloride is the only COPC that contributes a non-cancer risk in excess of the target HI of 1.0, with an HI equal to 1.14 or approximately 80% of the total HI. Ingestion of carbon tetrachloride in groundwater results in an HI of 0.959 (or 68% of the total HI). The results indicate that there may be unacceptable non-cancer risks associated with COPCs found in groundwater at this location. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-16.

5.10.2.4 Hypothetical Future Child Residents

On-Base PCE Plume: Carcinogenic risk probabilities are calculated for hypothetical future child residents who potentially may be exposed to COPCs in on-base groundwater from the PCE Plume. Table 5-35 shows that the overall cancer risk estimate for child residents is approximately 4.06×10^{-4}. PCE is the only COPC that has a cancer risk that exceeds 1×10^{-6}, with a cancer risk of 4.05×10^{-4} or 99.8% of the total cancer risk from all COPCs. All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest contributor being ingestion of groundwater, 3.21×10^{-4}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-8.

The total estimated HI for hypothetical on-base future child residents is 0.906 (shown in Table 5-35). Approximately 97% of the total HI is from exposure to PCE. Since the overall HI is estimated to be less than the target HI of 1.0, the likelihood of future child residents experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-8.

Off-Base PCE Plume: Carcinogenic and non-carcinogen risks calculated for hypothetical future off-base child residents are summarized in Table 5-40. Carcinogenic risk probabilities are calculated for hypothetical off-base residents that may be exposure to COPCs in groundwater from the PCE Plume via ingestion, dermal absorption, and inhalation. Table 5-40 shows that the overall cancer risk estimate for child residents is approximately 8.41×10^{-5}. The risks are mainly due to PCE (8.34×10^{-5} or 99%). All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest contributor being ingestion of groundwater, 6.51×10^{-5}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-12.

Non-carcinogenic risks are also calculated for hypothetical future child residents potentially exposed to COPCs in off-base groundwater associated with the PCE Plume (Table 5-40). The total HI is 0.188 which is below the target HI of 1.0. Since the overall HI is estimated to be less than the target HI of 1.0, the likelihood of future child residents experiencing adverse health effects is small. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-12.

North Plume: Carcinogenic risk probabilities were calculated for hypothetical future child residents who potentially may be exposed to COPCs in on-base groundwater associated with the North Plume. Residents are assumed to come into contact with COPCs in groundwater via ingestion, dermal contact, and inhalation of indoor air impacts by vapor intrusion. Table 5-46 shows that the total cancer risk for future hypothetical resident children is approximately 9.88×10^{-5}. Carbon tetrachloride, chloroform, 1,2-DCA, and TCE each contribute carcinogenic risks higher than 1×10^{-6}, with the majority of the risk from carbon tetrachloride (6.36×10^{-5} or 64%) and, in particular, from the ingestion of carbon tetrachloride in groundwater, 5.37×10^{-5}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-17.

Non-carcinogenic risks are also calculated for hypothetical future child residents potentially exposed to COPCs in groundwater associated with the North Plume over a lifetime (Table 5-46). Carbon tetrachloride is the only COPC that contributes a non-cancer risk in excess of the target HI of 1.0, with an HI equal to 2.64, approximately 80% of the total HI. Ingestion of carbon tetrachloride in groundwater results in a HI of 2.24 (or 68% of the total HI). The total HI was 3.29 which exceeds the target HI of 1.0, indicating there may be unacceptable non-cancer risks associated with COPCs found in groundwater at this location. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-17.

5.10.2.5 Hypothetical Future Residents (Lifetime)

On-Base PCE Plume: The calculated risks for hypothetical future adult and child residents can be added to obtain an estimate of lifetime risk. Carcinogenic risk probabilities for hypothetical future residents over a lifetime (child plus adult exposure) who potentially may be exposed to COPCs in on-base groundwater from the PCE Plume are presented in Table 5-36. The overall lifetime cancer risk estimate for residents is approximately 1.12×10^{-3}. PCE is the only COPC that exceeds the lower risk target level of 1×10^{-6}, with a cancer risk of 1.12×10^{-3} or 99.8% of the total cancer risk from all COPCs. All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest contributor being ingestion of groundwater, 8.72×10^{-4}. The estimated total cancer risk is above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}, indicating that further evaluation or action may be necessary.

The total estimated HI for hypothetical on-base future residents for lifetime exposure is 1.31 (shown in Table 5-36). Approximately 97% of the total HI or 1.27 is from exposure to PCE, with exposure via ingestion of groundwater contributing an HI of 0.992. The total HI exceeds the target HI of 1.0, indicating that there may be unacceptable non-cancer risks associated with PCE found in groundwater at this location.

Off-Base PCE Plume: The calculated risks for hypothetical future adult and child residents can be added to obtain an estimate of lifetime risk. Carcinogenic and non-carcinogen risks calculated for hypothetical future off-base residents for lifetime exposure are summarized in Table 5-41. Estimated carcinogenic risk probabilities show that the overall cancer risk estimate for lifetime residents is approximately 2.35×10^{-4}. The risks are mainly due to PCE (2.33×10^{-4} or 99%). All pathways for PCE exposure have risks higher than 1×10^{-6}, with the highest

contributor being ingestion of groundwater, $1.77x10^{-4}$. The cancer risk due to dermal contact with TCE in water, $1.41x10^{-6}$, also exceeds the lower target risk level of $1x10^{-6}$. The estimated total cancer risk is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$, indicating that further evaluation may be necessary.

Non-carcinogenic risks are also calculated for hypothetical future residents potentially exposed to COPCs in off-base groundwater associated with the PCE Plume over a lifetime (Table 5-41). The total HI is 0.277 which is below the target HI of 1.0. Since the overall HI is estimated to be less than the target HI of 1.0, the likelihood of future residents experiencing adverse health effects is small.

North Plume: The calculated risks for hypothetical future adult and child residents can be added to obtain an estimate of lifetime risk. Carcinogenic risk probabilities are calculated for hypothetical future residents who potentially may be exposed to COPCs in on-base groundwater associated with the North Plume over a lifetime. Table 5-47 shows that the total cancer risk for future hypothetical residents is approximately $2.94x10^{-4}$. Carbon tetrachloride, chloroform, 1,2-DCA, and TCE each contribute carcinogenic risks higher than $1x10^{-6}$, with the majority of the risk from carbon tetrachloride ($1.75x10^{-4}$ or ~60%) and, in particular, from the ingestion of carbon tetrachloride in groundwater, $1.46x10^{-4}$. The estimated total cancer risk is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$, indicating that further evaluation or action may be necessary.

The non-carcinogenic risk is also calculated for hypothetical future residents (Table 5-47). The total HI is 4.71 which exceeds the target HI of 1.0. Carbon tetrachloride is the only COPC that contributes a non-cancer risk in excess of the target HI of 1.0, with an HI equal to 3.78 or approximately 80% of the total HI. Ingestion of carbon tetrachloride in groundwater results in an HI of 3.20. The results indicate that there may be unacceptable non-cancer risks associated with COPCs found in groundwater at this location.

5.10.2.6 Current/Future Maintenance Workers

Carcinogenic risk probabilities were calculated for current or future maintenance workers potentially exposed to COPCs in surface water in East Toll Gate Creek. Table 5-37 shows that the overall cancer risk estimate for potential maintenance workers exposed to surface water is approximately $7.13x10^{-9}$. The risk estimate lies below the EPA lower target risk and the CDPHE target risk of $1x10^{-6}$, indicating that action at this site may not be necessary based on this receptor group. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-9.

Non-carcinogenic HIs are also calculated for maintenance workers potentially exposed to COPCs in surface water at East Toll Gate Creek (Table 5-37). The total HI was estimated at approximately $3.94x10^{-6}$ which is less than the target HI of 1.0. Since the overall HI is estimated to be less than 1.0, the likelihood of a current or future maintenance worker experiencing adverse health effects is considered negligible. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-9.

5.10.2.7 Current/Future Visitors

Carcinogenic risk probabilities are calculated for visitors (youths) potentially exposed to COPCs in surface water from East Toll Gate Creek (Table 5-42). The overall cancer risk estimate for potential visitors is to be 6.07×10^{-9}. This risk lies below the EPA lower target risk and the CDPHE target risk of 1×10^{-6}, indicating that action at the site may not be necessary based on this receptor group. Detailed calculations of carcinogenic risk for this receptor and location are shown in Table I-13.

Noncarcinogenic HIs are also calculated for future visitors potentially exposed to COPCs in surface water in East Toll Gate Creek (Table 5-42). The total HI was calculated to be 1.31×10^{-5}, less than the target HI of 1.0. Since the overall HI was estimated to be less than 1.0, the likelihood of visitors experiencing adverse health effects at East Toll Gate Creek is considered to be negligible. Detailed calculations of non-carcinogenic risk for this receptor and location are shown in Table I-13.

5.11 HUMAN HEALTH RISK UNCERTAINTY ANALYSIS

Uncertainty can be introduced into a health risk assessment at every step. Despite recent advances in risk assessment methodology, uncertainties are inherent in the risk assessment process. In order to appreciate the limitation and significance of the risk estimates, it is important to have an understanding of the sources and magnitudes of uncertainty. Sources of uncertainty in this risk assessment, as in any risk assessment, may include: 1) the identification of COPCs, 2) exposure assessment assumptions, and 3) limitations inherent in toxicity assessment. In addition to these sources of uncertainty, additional assumptions that also may contribute to the level of confidence that can be placed on the risk estimates have been introduced into the HHRA.

5.11.1 Uncertainties in Calculating the Concentration Term

Chemicals were selected as COPCs based on their maximum detected concentrations. For some COPCs, however, the frequency of detection may be low, with only one or a few detections in the whole dataset. Although EPA indicates that in some instances infrequently detected data may be screened out of an assessment (EPA, 1989), for this HHRA, any detected chemical that was above its screening level was maintained as part of the assessment. Additionally, using the maximum concentration as a representation of the overall concentration of a COPC may likely overestimate the risk. Maximum concentrations were chosen as the EPCs as a conservative estimate.

5.11.2 Uncertainties in the Exposure Assessment

Exposure assessment is perhaps the most critical step in achieving a reliable estimate of health risks to humans. In this assessment, a number of assumptions were made concerning the human populations that could come into contact with the media and the frequencies and durations of these contacts. The exposure parameters used in this assessment were largely based on EPA's RAGS, Part A (EPA, 1989), EPA's Exposure Factors Handbook (1997a), EPA's

RAGS, Part E (2004a), and the EPA's Supplemental Soil Screening Guidance (2002a) and may not be representative of the current and future receptor populations. There is also the presumption that interim and institutional measures at the site would not lead to changes in exposure conditions and receptor behaviors.

Recommended default values were assumed in order to represent the RME scenario for potential receptors. To ensure that risks were not underestimated, many of the assumptions made in the exposure analyses were selected because they were considered to be health protective. Most default exposure inputs in the dose calculations represent an upper bound estimate (i.e., 90th to 95th percentile). The combination of multiple 90th or 95th percentile RME default assumptions, which contribute to overestimation of plausible real-life exposures, combined with conservative toxicity criteria, can result in upper bound site risk estimates that may be over-protective.

Also, receptor groups that may not likely be found on the site in the future, such as residents, were assessed. Groundwater is not currently used for potable purposes at the evaluated locations and it is not expected to be used for that purpose in the future.

5.11.3 Environmental Media Sampling and Analysis

Sampling was conducted using accepted procedures in an attempt to collect samples that were representative of environmental media. Analyses were performed in accordance with the EPA QC procedures. Data were subsequently reviewed in a data review and validation process. However, current analytical procedures may not identify all potentially hazardous contaminants at a site, and analytical errors may have occurred despite stringent QA/QC procedures. In conducting this risk assessment, it was assumed that the reported chemical concentrations were representative of actual site conditions.

5.11.4 Chemical Transport and Fate

Migration, dispersion, dilution, retardation, degradation, and other attenuation or transformation processes may occur over time that could change the chemical concentrations in various on-base media. It has been conservatively assumed that the concentrations observed at the site will remain relatively unchanged with time; with the exception of VOCs and SVOCs, chemicals of potential concern are relatively persistent and immobile. Chemicals may degrade over time, although it was assumed that concentrations will stay constant over the assumed assessment period.

5.11.5 Toxicity Data

The available scientific data on toxic effects in humans for chemicals of concern found at Site 11 are limited. Consequently, varying degrees of uncertainty surround the assessment of adverse health effects in potentially exposed populations. Sources of uncertainty for toxic effects in humans include:

- Use of dose-response data from experiments on homogenous, sensitive animal populations to predict effects in heterogeneous human populations with a wide range of sensitivities (interspecies extrapolation)

- Extrapolation of data from high doses in animals to "real-world" low doses, from acute or subchronic to chronic exposure, and from one route to another, e.g., from ingestion to dermal absorption

- Use of single chemical data that do not account for possible antagonistic or synergistic responses from multiple chemical exposures

When dealing with exposures to chemical mixtures, EPA assumes dose additivity and does not account for potential synergisms, antagonisms, differences in target organ specificity, or mechanisms of action. Despite these many limitations, animal experiments are widely believed to be a necessary part of toxicity assessment, especially in the absence of human epidemiological data. The safety factors used in RfD derivations for single chemicals may compensate for any unknown effects of synergistic exposures.

5.12 RISK SUMMARY

The potential risks to hypothetical receptors at Site 11 (i.e., On-Base PCE Plume, Off-Base PCE Plume, and North Plume) have been estimated for receptor groups including future commercial workers, future construction workers, future residents (adult, child, and lifetime), current/future maintenance workers, and current/future recreational visitors that may come into contact with COPCs in groundwater or surface water. Cancer and non-cancer risks were calculated under baseline conditions and used RME assumptions. Summary risk tables for all receptors and pathways are presented in Tables 5-48 through 5-50.

COCs, those COPCs that contribute cancer risks which exceed $1x10^{-6}$ or HIs greater than 1.0 include:

<u>For On-Base PCE Plume:</u>

- PCE in groundwater

<u>For Off-Base PCE Plume:</u>

- PCE and TCE in groundwater

<u>For North Plume:</u>

- Carbon tetrachloride, chloroform, 1,2-DCA, and TCE in groundwater.

5.12.1 On-Base PCE Plume

The risks associated with groundwater from the On-Base PCE Plume are shown in Table 5-48. The excess carcinogenic risks estimated for commercial and construction workers are approximately $4.12x10^{-4}$ and $1.83x10^{-7}$, respectively. The total risk estimate for construction

workers is below the EPA lower target risk and the CDPHE target risk of $1x10^{-6}$, although the risk for commercial workers is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. Lifetime cancer risks for hypothetical residential adults and children were conservatively estimated at $1.12x10^{-3}$ ($7.12x10^{-4}$ and $4.06x10^{-4}$ for adults and children, respectively) which exceeds the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$.

For the On-Base PCE Plume, noncarcinogenic risks calculated for commercial and construction workers are approximately 0.221 and 0.0160, respectively. Both HIs are below the target HI of 1.0, indicating the likelihood of these workers experiencing adverse health effects is considered negligible. The HI associated with the lifetime exposure of hypothetical residential adults and children to COPCs identified with the On-Base PCE Plume is conservatively estimated at 1.31 (0.404 and 0.906 for adults and children, respectively) which exceeds the target HI of 1.0.

5.12.2 Off-Base PCE Plume

Table 5-49 shows the risks associated with groundwater from the Off-Base PCE Plume. The total excess carcinogenic risk estimated for construction workers is $7.82x10^{-7}$. This total risk estimate is below the EPA lower target risk and the CDPHE target risk of $1x10^{-6}$. Lifetime cancer risks for hypothetical residential adults and children were conservatively estimated at $2.35x10^{-4}$ ($1.51x10^{-4}$ and $8.41x10^{-5}$ for adults and children, respectively) which exceeds the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$.

For the Off-Base PCE Plume, noncarcinogenic risk calculated for construction workers is estimated at 0.0596. HI associated with the lifetime exposure of hypothetical residential adults and children to COPCs identified with the Off-Base PCE Plume was conservatively estimated at 0.277 (0.0888 and 0.188 for adults and children, respectively). The overall HIs are estimated to be less than 1.0, thus, the likelihood of the evaluated receptor groups experiencing adverse health effects is considered negligible.

5.12.3 Off-Base Surface Water

Risks associated with exposure to PCE (the only COPC identified) in off-base surface water in East Toll Gate Creek were also evaluated and are presented in Table 5-49. Current/future maintenance workers and visitors both have carcinogenic and non-carcinogenic risks below the corresponding levels of concern (i.e., cancer risk of $1x10^{-6}$ and HI of 1.0).

5.12.4 North Plume

The risks associated with groundwater from the North Plume are shown in Table 5-50. The excess carcinogenic risks estimated for commercial and construction workers are approximately $1.06x10^{-4}$ and $6.15x10^{-7}$, respectively. The total risk estimate for construction workers is below the EPA lower target risk and the CDPHE target risk of $1x10^{-6}$. The total carcinogenic risk for commercial workers is above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. Lifetime cancer risks for hypothetical residential adults and children

were conservatively estimated at 2.94×10^{-4} (1.95×10^{-4} and 9.88×10^{-5} for adults and children, respectively) which exceeds the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}.

For the North Plume, noncarcinogenic risks calculated for commercial and construction workers are approximately 0.878 and 0.109, respectively. Both HIs are below the target HI of 1.0, indicating the likelihood of these workers experiencing adverse health effects is considered negligible. The HI associated with the lifetime exposure of hypothetical residential adults and children to COPCs identified with the North Plume was conservatively estimated at 4.71 (1.42 and 3.29 for adults and children, respectively), which exceeds the target HI of 1.0.

5.13 RISK CONCLUSIONS

In conclusion, for the current potential uses and receptors of the Site 11 plume areas, RME cancer risks are not above EPA's lowest and CDPHE's target level of 1×10^{-6}, and non-cancer effects are not expected. This is based on evaluation of current off-base visitors and maintenance workers who may contact the surface water and sediment in East Toll Gate Creek. It is also based on a potential construction worker who may inhale vapors from groundwater in a trench, and, for off-base work, because the groundwater is shallower, may also be exposed to groundwater through incidental ingestion and dermal contact.

Although no construction of commercial buildings over the on-base Site 11 plumes is planned, in the future, if a commercial building is constructed, occupants may be exposed to the groundwater contaminants through inhalation of vapors in indoor air. Additionally, although highly unlikely, they may use the groundwater for drinking water. Under this scenario, the RME cancer risks for both the North Plume and On-Base PCE Plume exceed the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}. However, for the indoor air pathway, which is the most likely exposure pathway under this scenario, the risks (1.36×10^{-6} and 1.08×10^{-5}, respectively) are within EPA's risk range of 10^{-6} to 10^{-4}, although they exceed CDPHE's target cancer risk of 1×10^{-6}. Non-cancer effects are not expected.

Even less plausible for the Site 11 on-base and off-base plume areas, is the scenario that residents would occupy houses over the plumes, and use the groundwater for drinking water and showering/bathing. In addition, these hypothetical residents could be exposed to vapors in indoor air from the groundwater. Under this scenario, for all the Site 11 plume areas, the RME cancer risks for the sum of all three exposure pathways for lifetime residents are above the 1×10^{-4} EPA action level and the CDPHE target cancer risk of 1×10^{-6}. Of these, the indoor air exposure pathway has the lowest risk, ranging from 6.84×10^{-6} (On-Base PCE Plume), 8.30×10^{-6} (Off-Base PCE Plume), to 5.44×10^{-5} (North Plume). Non-cancer HIs for the On-Base PCE Plume and the North Plume, 1.31 and 4.71, respectively, slightly exceed the target HI of 1.0, indicating potential non-cancer health effects if the groundwater is used for drinking water by residents.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The March 2009 through September 2010 RI work at Site 11 was conducted to delineate the extent of chlorinated solvent contamination detected in two wells installed during the Triad SI, with the priority to determine whether groundwater contamination was migrating off base. Prior to the RI, it was known that a groundwater sample from one well (1011MW06) was contaminated with PCE above the CBSG, and a groundwater sample from another well (1011MW07) was contaminated with TCE, 1,2-DCA, carbon tetrachloride, and chloroform above CBSGs. The sources and upgradient and downgradient extents of the contamination were not known. However, it was interpreted that the PCE contamination at well 1011MW06 occurred in an alluvial paleochannel that appeared to influence the groundwater flow and contaminant migration near this well. Under the RI, the source areas and extents of the groundwater contamination were delineated; the paleochannel, which is the preferential contaminant migration pathway for the PCE contamination in groundwater, was delineated to increase the understanding of the groundwater flow direction and contaminant migration; the hydrogeologic conditions were assessed; and the potential impact of the off-base migration of PCE contamination was assessed for surface water, sediment, and groundwater. In addition, 1,4-dioxane, which was commonly used as a solvent stabilizer and also in painting-related products, was eliminated as a potential contaminant of concern.

6.1 CONCLUSIONS

This RI documents the results of an extensive investigation of groundwater and associated media, including surface water and sediment, potentially affected by contaminant conditions in groundwater underlying Site 11. Previously collected groundwater data have also been evaluated for this report. The data are considered adequate to enable the future evaluation and selection of remedial alternatives in the FS for the two chlorinated solvent groundwater plumes. No additional remedial actions or monitoring are warranted for the petroleum LNAPL at the Building 710 area near the southeast end of Site 11.

Under the RI, two mappable groundwater contaminant plumes at Site 11 with contaminants above CBSGs were identified: the PCE Plume and the North Plume. The PCE Plume, based on concentrations above the CBSG of 5 µg/L, is about 1,100 feet long, with about 400 feet of the plume off base. The highest detected PCE concentration was 157 µg/L in well 11MW05; however, the next highest concentration in this well, which was sampled three times during the RI, was 71.5 µg/L. No DNAPL is suspected, based on the low concentration compared to the solubility. The highest off-base concentration of PCE was 22 µg/L, detected in a groundwater grab sample north of East Toll Gate Creek. The source of the PCE Plume is south of the east end of former Building 1011, near a paved, bermed area. There may have been spills of PCE from potential drums or other containers that may have been near or within the curbed area, or, although no historical information has been found, potentially a subsurface drain line or vessel. The data indicate there is not a significant residual source of contaminants in the soil. In this area, the groundwater contamination is within in a weathered Denver Formation sandstone. Downgradient migration occurs primarily to the southwest-west within an alluvial paleochannel incised in the bedrock surface that was filled with relatively coarse alluvial material. Off-base groundwater appears to discharge to East Toll Gate Creek, at least seasonally, in the portion of

the creek near the PCE Plume. Further downgradient, in addition to upgradient (on-base) the creek has been observed to be dry (e.g., October 2009). Degradation of PCE is occurring at the off-base portion of the plume near East Toll Gate Creek. The creek appears to be impacting degradation of the PCE, potentially by several routes, including volatilization/oxygenation, decaying organic matter, root activity, and plant uptake. Concentrations of PCE and its degradation products (TCE, cis-1,2-DCE) in the surface water and sediment do not exceed water standards or soil screening levels. It is unlikely the plume will migrate across (south of) the creek or significantly farther downgradient at high levels based on these ongoing conditions.

The North Plume consists of combined plumes of TCE, 1,2-DCA, carbon tetrachloride, and chloroform. The highest concentrations of TCE (65.8 μg/L), chloroform (93.8 μg/L), and carbon tetrachloride (140 μg/L), are about an order of magnitude higher than their CBSGs. The most soluble of these solvents, chloroform, has the most widespread distribution above its CBSG, while the other three solvents have remained close to the source at high concentrations. None of these contaminants were detected above CBSGs at the base boundary (well 11MW03). The chloroform plume is about 220 feet long. The groundwater occurs within weathered bedrock including claystone, siltstone, and minor amounts of sandstone, typically clayey or silty, with low hydraulic conductivity. The most permeable material was observed where the concentrations were highest (well 1011MW07), including a 3-foot-thick wet, loose, fine- to medium-grained sandstone. The source of the contamination is within or adjacent to a landscaped area that contains a 10,000-gallon UST installed to hold gasoline at a service station beginning in the late 1940s. These VOCs were likely associated with vehicle repair or other similar activities in former Building 1011 that may have been released to the ground in or near the landscaped area, as there are no known utility lines or drains from the auto repair shop. The 1,2-DCA may have also been a component of paint, varnish, and finish removers, or potentially a scavenging agent in leaded gasoline in the UST. The data indicate there is not a significant residual source of contaminants in the soil. The permeable sandy fill material surrounding this UST has likely contributed to the migration of contaminants in this immediate area, both laterally and vertically. However, downgradient to the southwest, the hydraulic conductivity of the zone with contaminated groundwater is lower, which has limited the migration of contamination. In addition, degradation of carbon tetrachloride to chloroform and methylene chloride by reductive chlorination appears to be occurring, potentially helped by low levels of cometabolites in the form of petroleum hydrocarbons at the UST area.

The Baseline HHRA indicated for the current potential uses and receptors of the Site 11 plume areas, RME cancer risks are not above EPA's lowest and CDPHE's target level of $1x10^{-6}$, and non-cancer effects are not expected. This is based on evaluation of current off-base visitors and maintenance workers who may contact the surface water and sediment in East Toll Gate Creek. It is also based on a potential construction worker who may inhale vapors from groundwater in a trench, and, for off-base work, because the groundwater is shallower, may also be exposed to groundwater through incidental ingestion and dermal contact. There are no known completed direct exposure pathways to human receptors from groundwater within the currently defined extent of groundwater contamination described in this RI.

Although no construction of commercial buildings over the on-base Site 11 plumes is planned, in the future, if a commercial building is constructed, occupants may be exposed to the

groundwater contaminants through inhalation of vapors in indoor air. Additionally, although highly unlikely, they may use the groundwater for drinking water. Under this scenario, the RME cancer risks for both the North Plume and On-Base PCE Plume exceed the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. However, for the indoor air pathway, which is the most likely exposure pathway under this scenario, the risks ($1.36x10^{-6}$ and $1.08x10^{-5}$, respectively) are within EPA's risk range of 10^{-6} to 10^{-4}, although they exceed CDPHE's target cancer risk of $1x10^{-6}$. Non-cancer effects are not expected.

Even less plausible for the Site 11 on-base and off-base plume areas, is the scenario that residents would occupy houses over the plumes, and use the groundwater for drinking water and showering/bathing. In addition, these hypothetical residents could be exposed to vapors in indoor air from the groundwater. Under this scenario, for all the Site 11 plume areas, the RME cancer risks for the sum of all three exposure pathways for lifetime residents are above the $1x10^{-4}$ EPA action level and the CDPHE target cancer risk of $1x10^{-6}$. Of these, the indoor air exposure pathway has the lowest risk, ranging from $6.84x10^{-6}$ (On-Base PCE Plume), $8.30x10^{-6}$ (Off-Base PCE Plume), to $5.44x10^{-5}$ (North Plume). Non-cancer HIs for the On-Base PCE Plume and the North Plume, 1.31 and 4.71, respectively, slightly exceed the target HI of 1.0, indicating potential non-cancer health effects if the groundwater is used for drinking water by residents.

Based on assessment of risk associated with exposure to groundwater, sediment, and surface water, the following chemicals (COCs) associated with previous site operations are found at levels that may pose an unacceptable risk to potential future human populations:

<u>On-Base PCE Plume:</u>

- PCE in groundwater

<u>Off-Base PCE Plume:</u>

- PCE and TCE in groundwater

<u>North Plume:</u>

- Carbon tetrachloride, chloroform, 1,2-DCA, and TCE in groundwater.

6.2 RECOMMENDATIONS

This RI report marks the completion of the RI phase of the CERCLA process for Site 11 groundwater. The FS phase will rely on the RI data as a basis for remedial evaluations and design. In addition, monitoring of the groundwater contaminants, and if needed, collection of supplemental data in specific plume areas targeted for remedial action under the FS, would be appropriate to help ensure that appropriate and effective remedial measures are implemented.

The following remedial action objectives (RAOs), which are medium-specific goals for protection of human health and the environment, are proposed for the Site 11 chlorinated solvent groundwater plumes:

- Prevent ingestion of and direct contact with impacted groundwater until concentrations have been reduced to levels that allow unrestricted use and unlimited exposure (i.e., CBSGs or MCLs)

- Prevent vapors that may originate from impacted groundwater from accumulating to unacceptable levels in indoor air of potential future buildings

- Restore groundwater to beneficial use, where restoration means reducing concentrations of contaminants in groundwater to their respective CBSGs or MCLs via engineered and/or natural processes.

Regular monitoring of the Site 11 wells for the two plume areas is recommended to assess concentration trends for the VOCs of concern over time. Monitoring for natural attenuation parameters may also be warranted to assess biodegradation processes acting on chlorinated solvent contamination in groundwater at Site 11, and support whether further study or evaluation should be considered. As needed to support remedy evaluation, collection of additional hydrogeologic, physical, and chemical data may be warranted, such as in the source areas or near the base boundary.

Off-base well 11MW14 was constructed as a temporary well in May 2010 using direct-push methods; groundwater has been slow to enter the well and was not fully stabilized by September 10, 2010, which may be partially attributable to mud smearing along the walls of the boring. Either conversion of this well to a permanent monitoring well, which will need to be licensed by the City of Aurora, or installation of another well off base north of East Toll Gate Creek, is recommended to monitor the downgradient end of the PCE Plume. These alternatives could be more fully evaluated after the water level has stabilized, and another round of sampling has been conducted.

Discontinuance of the petroleum LNAPL removal and monitoring program at the Building 710 area near the southeast end of Site 11 is recommended. Upon regulatory approval, the two sorbent socks should be removed from the wells and properly disposed, and wells that are not needed to support future Site 11 work should be abandoned. It is recommended that well 710MW03 be retained, and the other four LNAPL monitoring wells (710MW01, 710MW02, 710MW04, and MW710-1) be abandoned.

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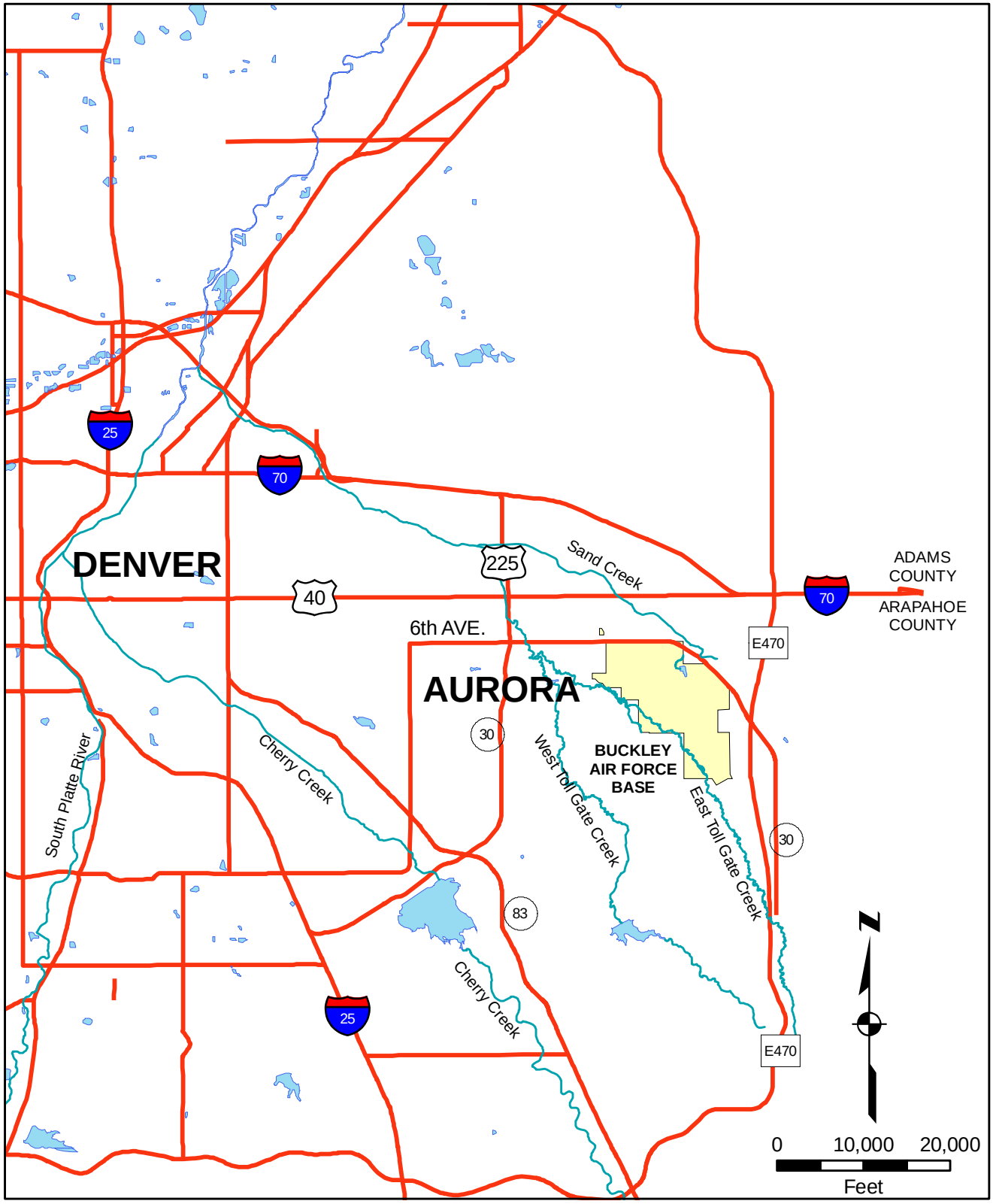


25 INTERSTATE HIGHWAY

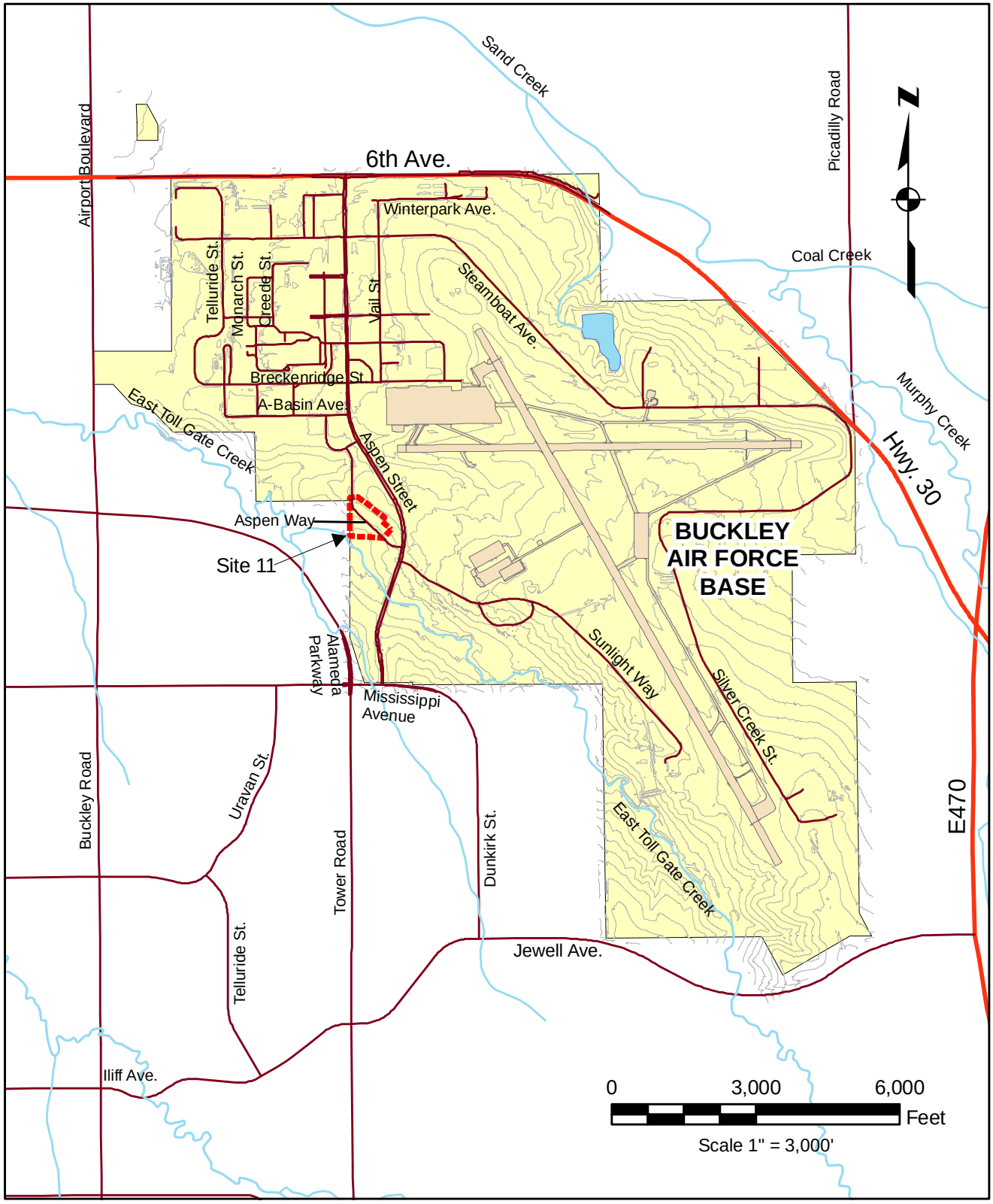
40 U.S. HIGHWAY

30 STATE

E470 TOLL ROAD

VicinityMap.mxd

Figure 1-1
Vicinity Map
Buckley Air Force Base

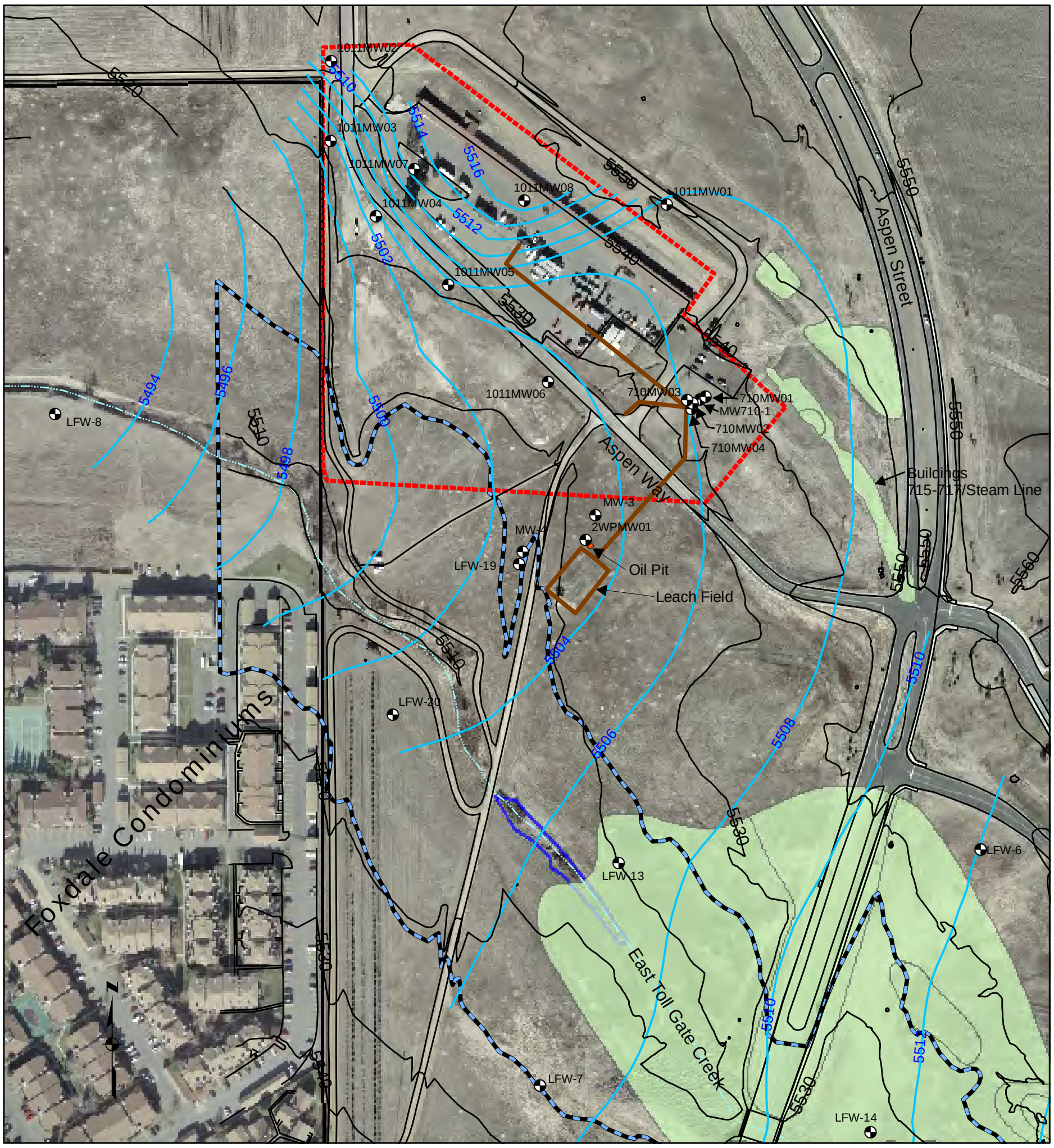


Legend

- Initial Site 11 Boundary
- Topographic Contour (10 Feet)
- Streams
- Roads

Figure 1-2
Site 11
Location Map
Buckley Air Force Base

LocationMap-9-10.mxd



2001 Merrick Aerial

Legend

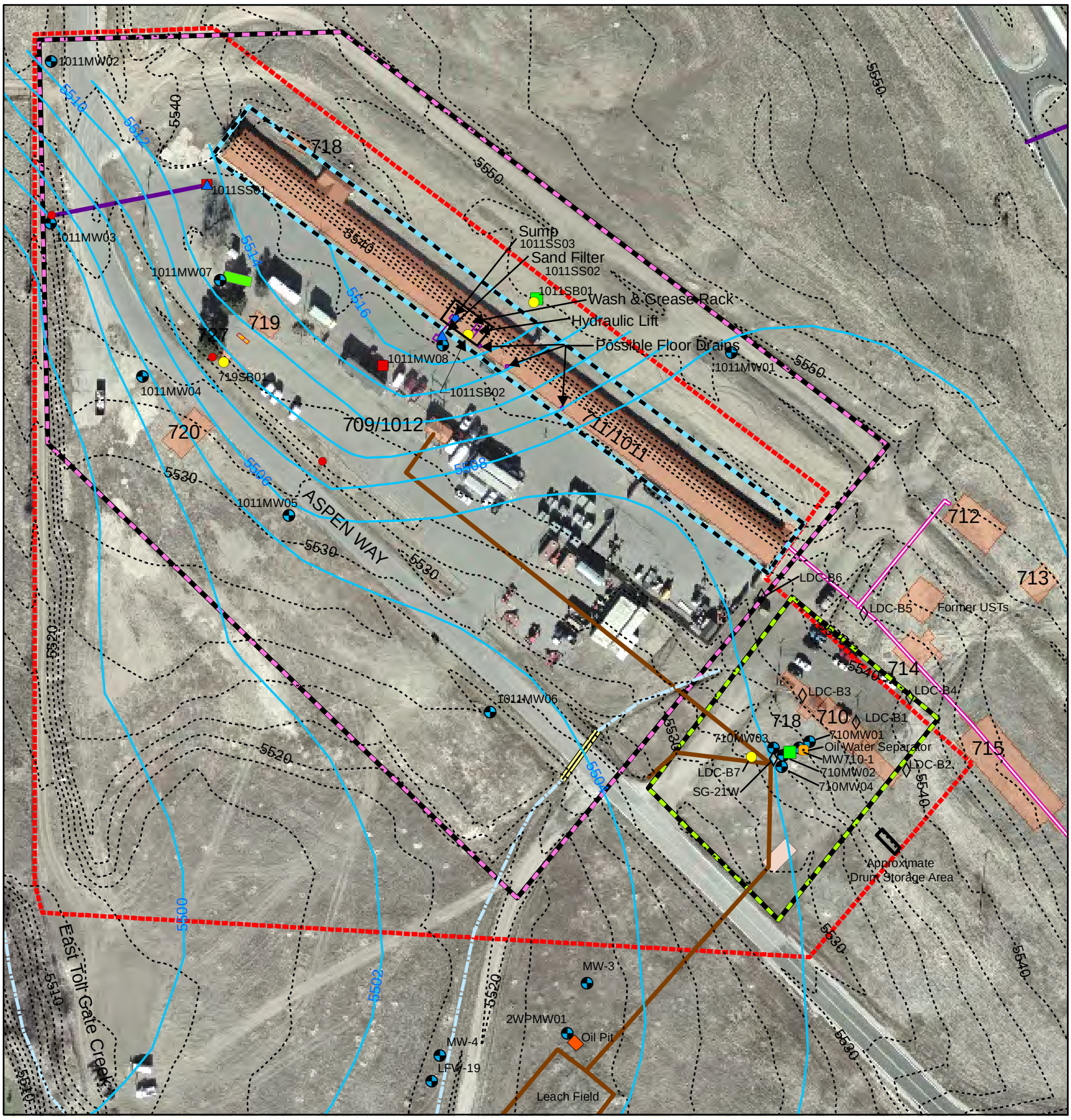
- Monitoring Well Installed Prior to Site 11 RI
- Wastewater Line
- Existing Ground Contour (10' Interval)
- Potentiometric Contour (June 06)
- Roads
- Streams
- Site 2 Oil Pit
- Initial Site 11 Boundary
- 100 Year Flood Plain
- Site 3 Landfill Areas (07)
- Wetlands (Summer 04)
- Buckley Boundary

N

0 200 400
Feet

Figure 1-3
Previous Features for Site 11
and Adjacent Sites
Buckey Air Force Base

Previous Features-09-10.mxd



2001 Merrick Aerial

Legend

- Steam Line
- Wastewater Line
- Storm Sewer Open Drainage
- Storm Sewer Line
- Storm Sewer Culvert
- Initial Site 11 Boundary
- Septic Tank
- Firing Tunnel Investigation Area
- LNAPL Investigation Area
- Other Potential Sources Investigation Area
- Pump Island
- Topographic Contour
- Potentiometric Contour (June 06)
- Monitoring Well Installed Prior to Site 11 RI
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Previous Temporary Well
- Catch Basin
- Underground Storage Tank
- Former Structure

N

0 50 100 200
Feet

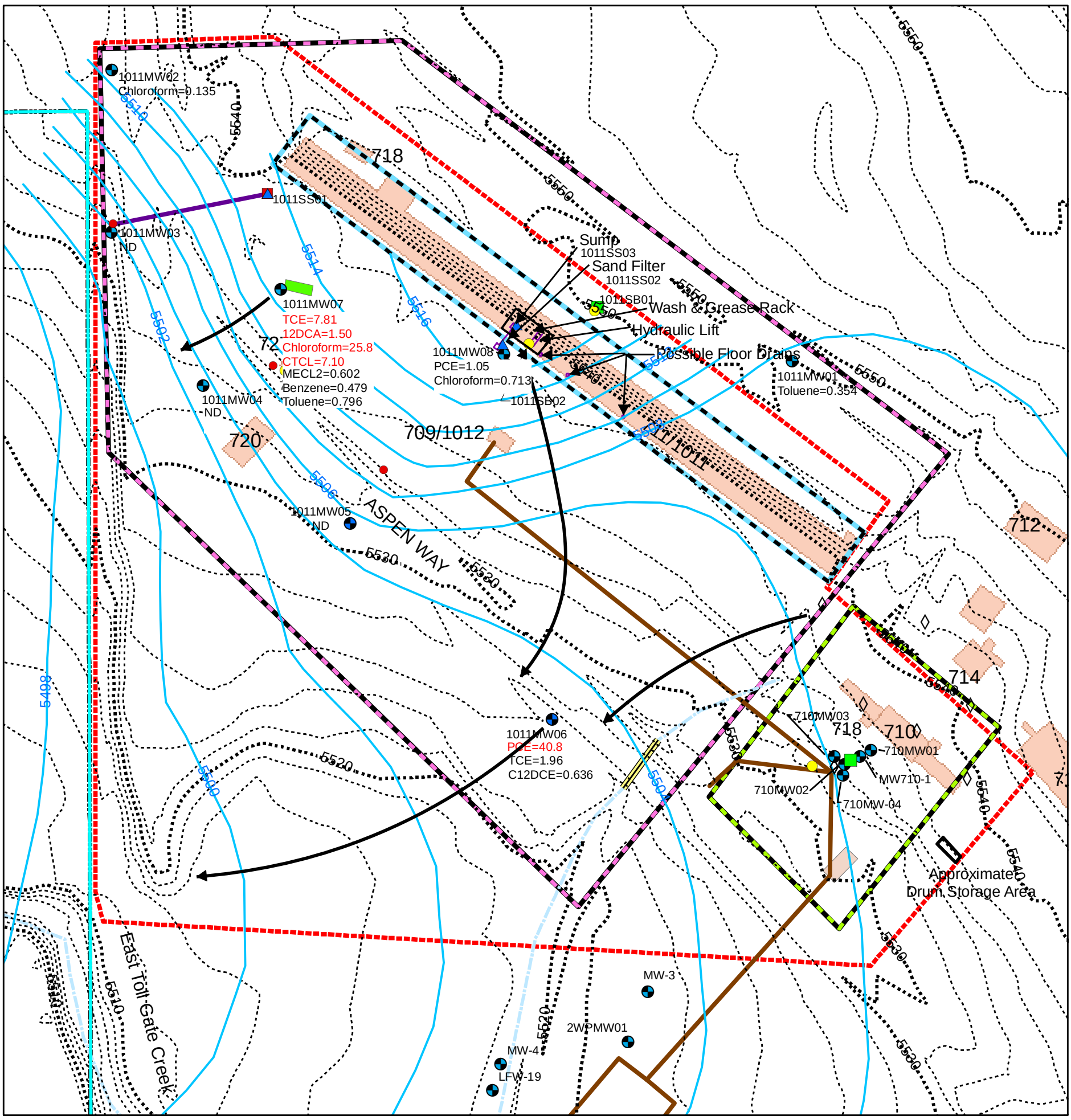
Figure 1-4
Previously Investigated Potential Source Areas
Buckley Air Force Base

SourceAreas-09-10.mxd

0 100 200
Feet

Figure 1-5
Site 11 Aerial Photo
March 30, 1971
Buckley Air Force Base

Aerial-3-30-71_site11.mxd



Legend

- Base Boundary
- Wastewater Line
- Storm Sewer Open Drainage
- Storm Sewer Line
- Storm Sewer Culvert
- Initial Site 11 Boundary
- Septic Tank
- Firing Tunnel Investigation Area
- LNAPL Investigation Area
- Other Potential Sources Investigation Area
- Pump Island
- Topographic Contour
- Potentiometric Contour 6/06
- Groundwater Flow
- Monitoring Well Installed Prior to Site 11 RI
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Previous Temporary Well
- Catch Basin
- Underground Storage Tank
- Former Structure

N

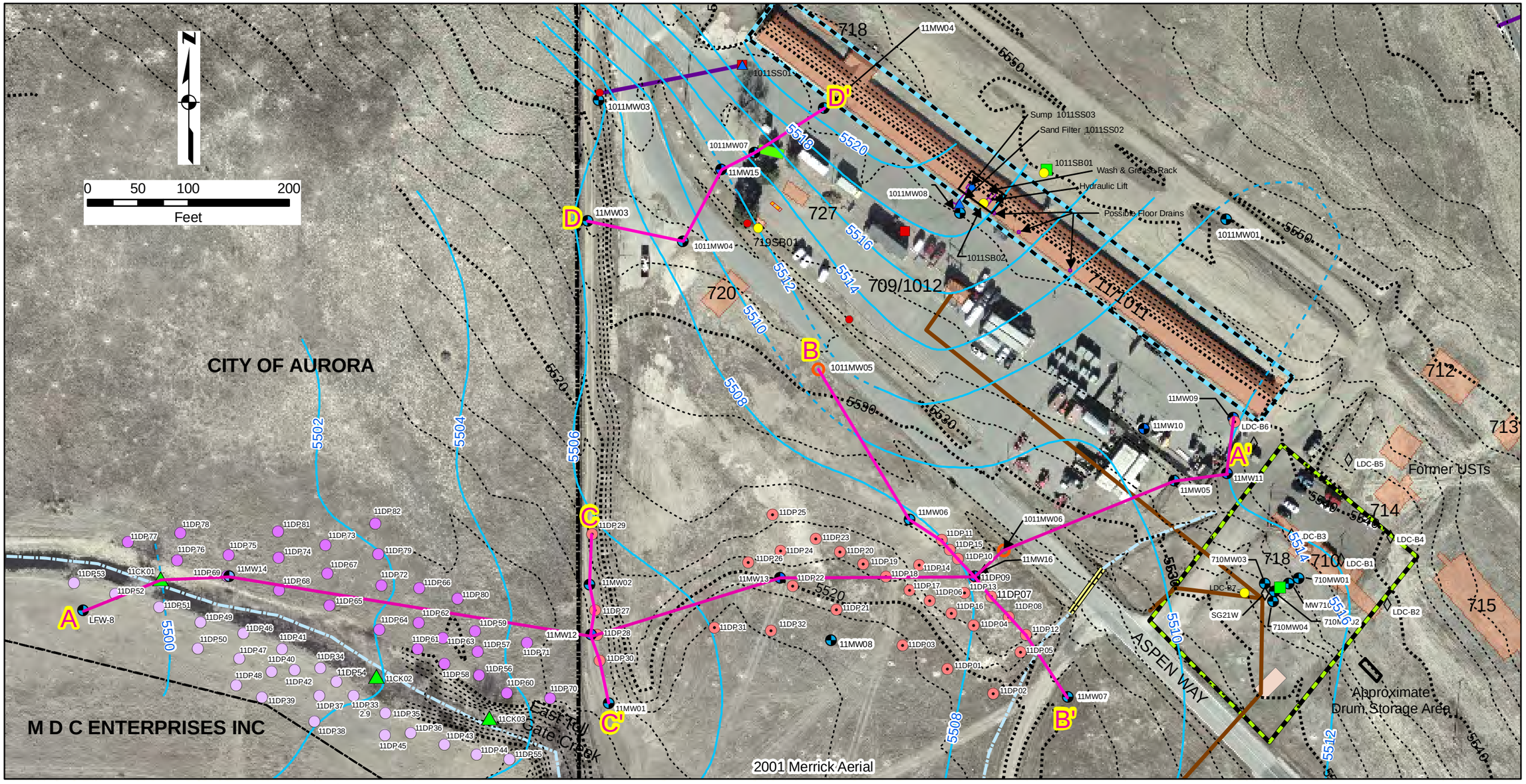
0 50 100 200
Feet

Notes:
Concentrations are in micrograms per liter.
Analytes and concentrations are shown in "red" text where concentrations exceed CBSGs.

12DCA - 1,2-dichloroethane
C12DCE - cis-1,2-dichloroethene
CBSG - Colorado Basic Standard for Groundwater (Reg. 41)
CTCL - carbon tetrachloride
MECL2 - methylene chloride
ND - not detected
PCE - tetrachloroethene
TCE - trichloroethene
VOC - volatile organic compound

Figure 1-6
Detections of VOCs with Groundwater Standards in 2006 Other Potential Sources Investigation
Buckley Air Force Base

Site11_VOC-09-10.mxd

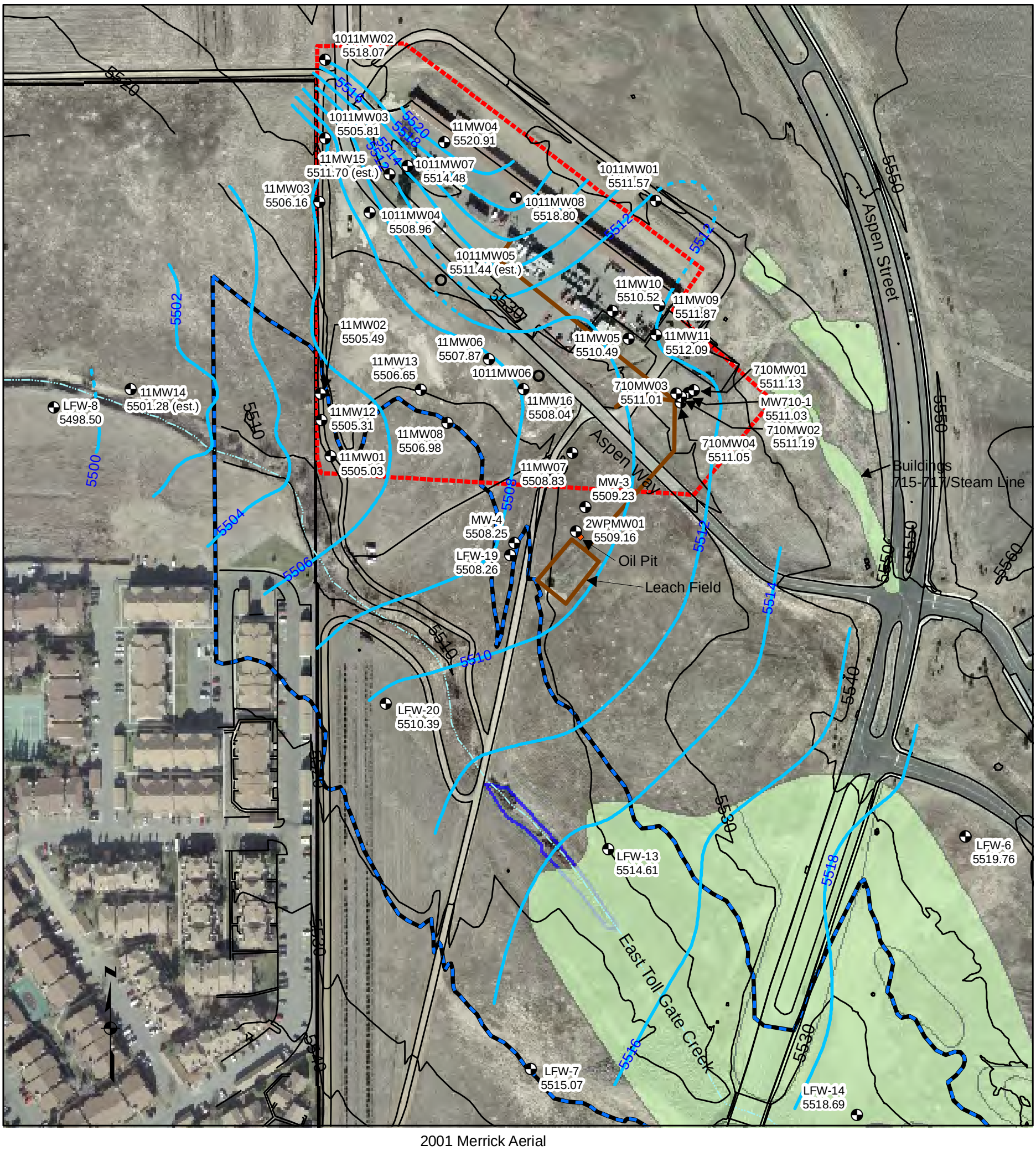


Legend

- Monitoring Well
- Groundwater Grab Sampling Location (6/09)
- Groundwater Grab Sampling Location (5/10)
- Groundwater Grab Sampling Location (2/10)
- Abandoned Monitoring Well
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Abandoned Temporary Well
- Catch Basin
- Underground Storage Tank
- Surface Water and Sediment Sample
- Potentiometric Contour (June 10) Dashed Where Inferred
- Topographic Contour
- Storm Sewer Culvert
- Storm Sewer Line
- Storm Sewer Open Drainage
- Wastewater Line
- Base Boundary
- Pump Island
- Firing Tunnel Investigation Area
- LNAPL Investigation Area
- Septic Tank
- Former Structure
- Property Parcel Boundary (Arapahoe County on-line GIS 7/09)
- A — A' Cross Section

Figure 2-1
Sample and Cross-Section Locations
Site 11 RI
Buckley Air Force Base

GIS\BUCKLEY\Cross_Sections_09-10.mxd



2001 Merrick Aerial

Legend

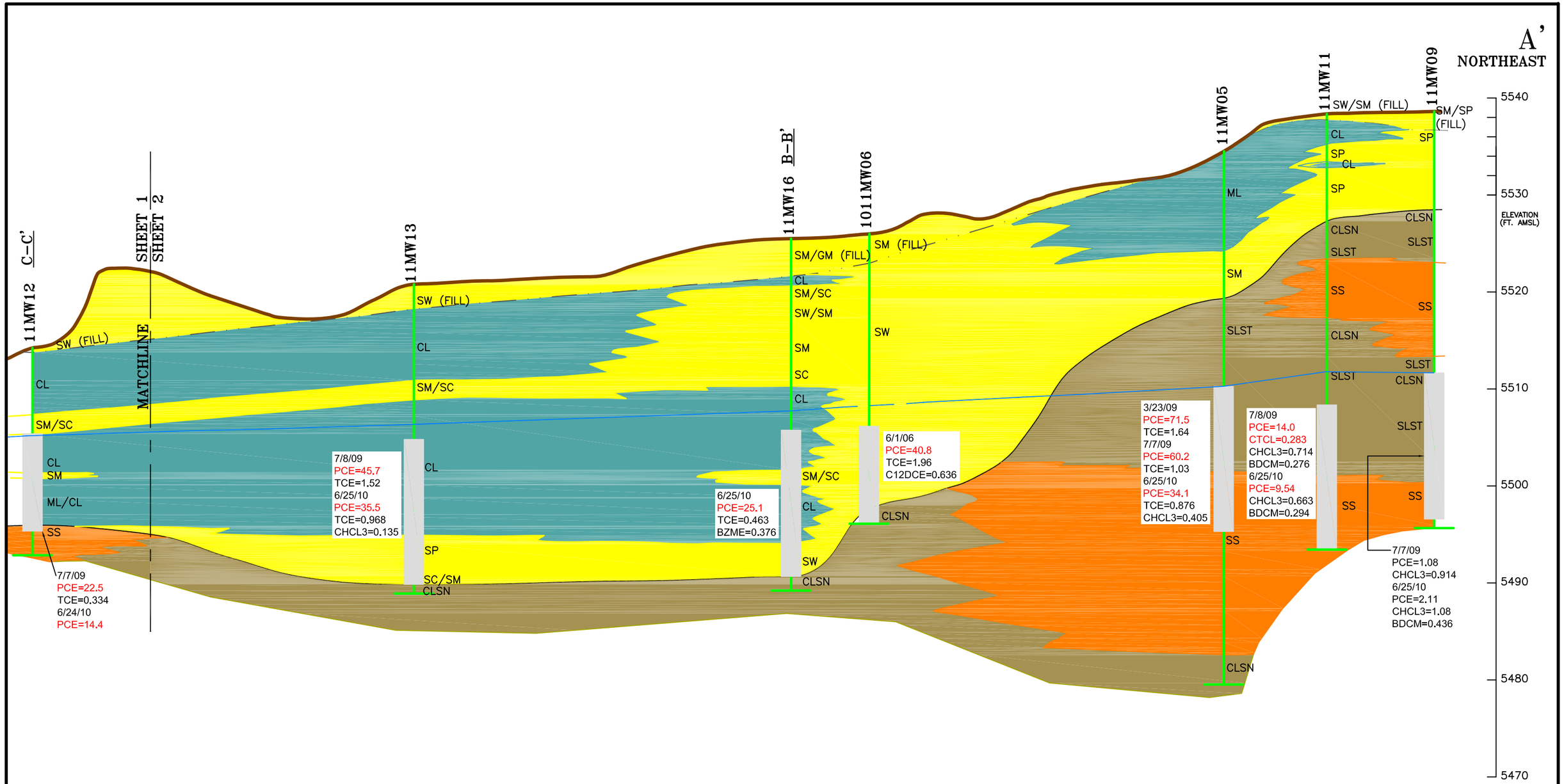
- Monitoring Well
- Abandoned Monitoring Well
- Wastewater Line
- Existing Ground Contour (10' Interval)
- Potentiometric Contour (June 10), dashed where inferred
- Roads
- Streams
- Site 2 Oil Pit
- Initial Site 11 Boundary
- 100 Year Flood Plain
- Site 3 Landfill Areas (07)
- Wetlands (Summer 04)
- Buckley Boundary

N

0 200 400
Feet

Figure 3-1
June 2010 Potentiometric Surface
Site 11 and Adjacent Sites
Buckley Air Force Base

Potentiometric-06-10.mxd



EXPLANATION

INTERSECTING CROSS SECTON — B–B' 1011MW07

= GROUND SURFACE

= ALLUVIUM/BEDROCK CONTACT DASHED WHERE INFERRED

= POTENTIOMETRIC SURFACE (JUNE 2010), DASHED WHERE INFERRED

— WELL I.D.

— SCREEN INTERVAL

— TOTAL DEPTH

= CLAY AND SILT

= SAND

= SANDSTONE

= UNDIFFERENTIATED BEDROCK (DENVER FORMATION SILTSTONE AND CLAYSTONE EXCEPT WHERE NOTED)

CH = CLAY (HIGH PLASTICITY)
CL = CLAY
CLSN = CLAYSTONE
ML = SILT
SC = CLAYEY SAND
SLST = SILTSTONE
SM = SILTY SAND
SP = POORLY GRADED SAND
SS = SANDSTONE
SW = WELL GRADED SAND

TCE=50 = CONCENTRATION OF DETECTED ANALYTE IN MICROGRAMS PER LITER

VOCs=ND = NO SELECT VOLATILE ORGANIC COMPOUNDS (VOCs) DETECTED

3/23/09 = DATE SAMPLED

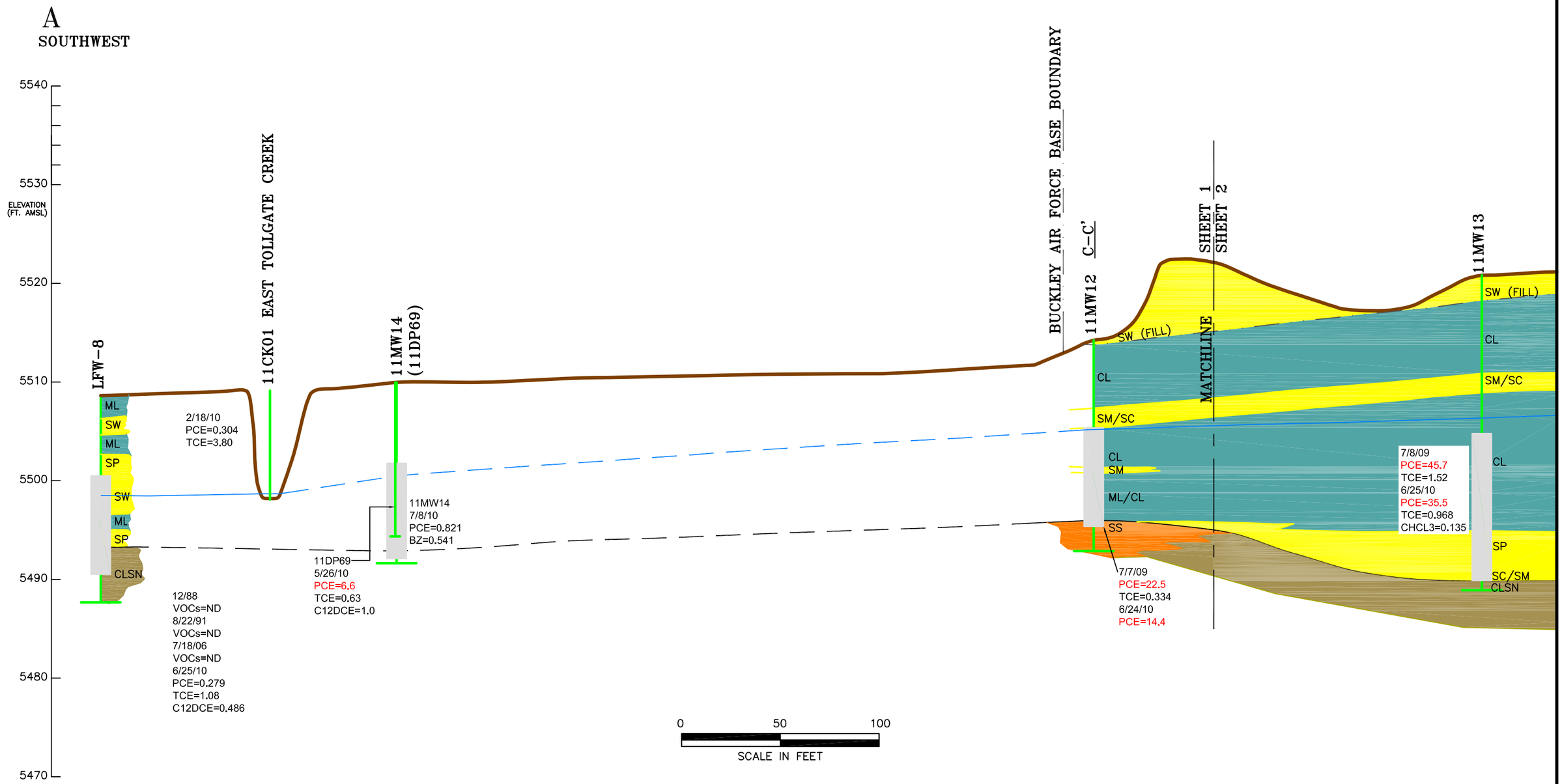
ANALYTES AND CONCENTRATIONS ARE SHOWN IN "RED" TEXT WHERE CONCENTRATIONS EXCEED COLORADO BASIC STANDARDS FOR GROUNDWATER.

ABBREVIATIONS OF SELECT VOCs

CHCL3 = CHLOROFORM
CTCL = CARBON TETRACHLORIDE
C12DCE= cis–1,2–DICHLOROETHENE
MECL2 = METHYLENE CHLORIDE
BDCM = BROMDICHLOROETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
BZ = BENZENE
BZME = TOLUENE
12DCA = 1,2=DICHLOROETHANE

FIGURE 3-2
PCE PLUME
CROSS SECTION A-A'
SHEET 1
SHOWING SELECT VOCs
SITE 11 RI
BUCKLEY AIR FORCE BASE
COLORADO

Q:\BUCKLEY\111750–003\XSECT–A–A'–9–10.DWG



EXPLANATION

- = GROUND SURFACE
- = ALLUVIUM/BEDROCK CONTACT DASHED WHERE INFERRED
- = POTENTIOMETRIC SURFACE (JUNE 2010), DASHED WHERE INFERRED

INTERSECTING CROSS SECTON — B–B'

1011MW07 — WELL I.D.

— SCREEN INTERVAL

— TOTAL DEPTH

- = CLAY AND SILT
- = SAND
- = SANDSTONE
- = UNDIFFERENTIATED BEDROCK (DENVER FORMATION SILTSTONE AND CLAYSTONE EXCEPT WHERE NOTED)

CH = CLAY (HIGH PLASTICITY)
CL = CLAY
CLSN = CLAYSTONE
ML = SILT
SC = CLAYEY SAND
SLST = SILTSTONE
SM = SILTY SAND
SP = POORLY GRADED SAND
SS = SANDSTONE
SW = WELL GRADED SAND

TCE=50 = CONCENTRATION OF DETECTED ANALYTE IN MICROGRAMS PER LITER

VOCs=ND = NO SELECT VOLATILE ORGANIC COMPOUNDS (VOCs) DETECTED

3/23/09 = DATE SAMPLED

ANALYTES AND CONCENTRATIONS ARE SHOWN IN "RED" TEXT WHERE CONCENTRATIONS EXCEED COLORADO BASIC STANDARDS FOR GROUNDWATER.

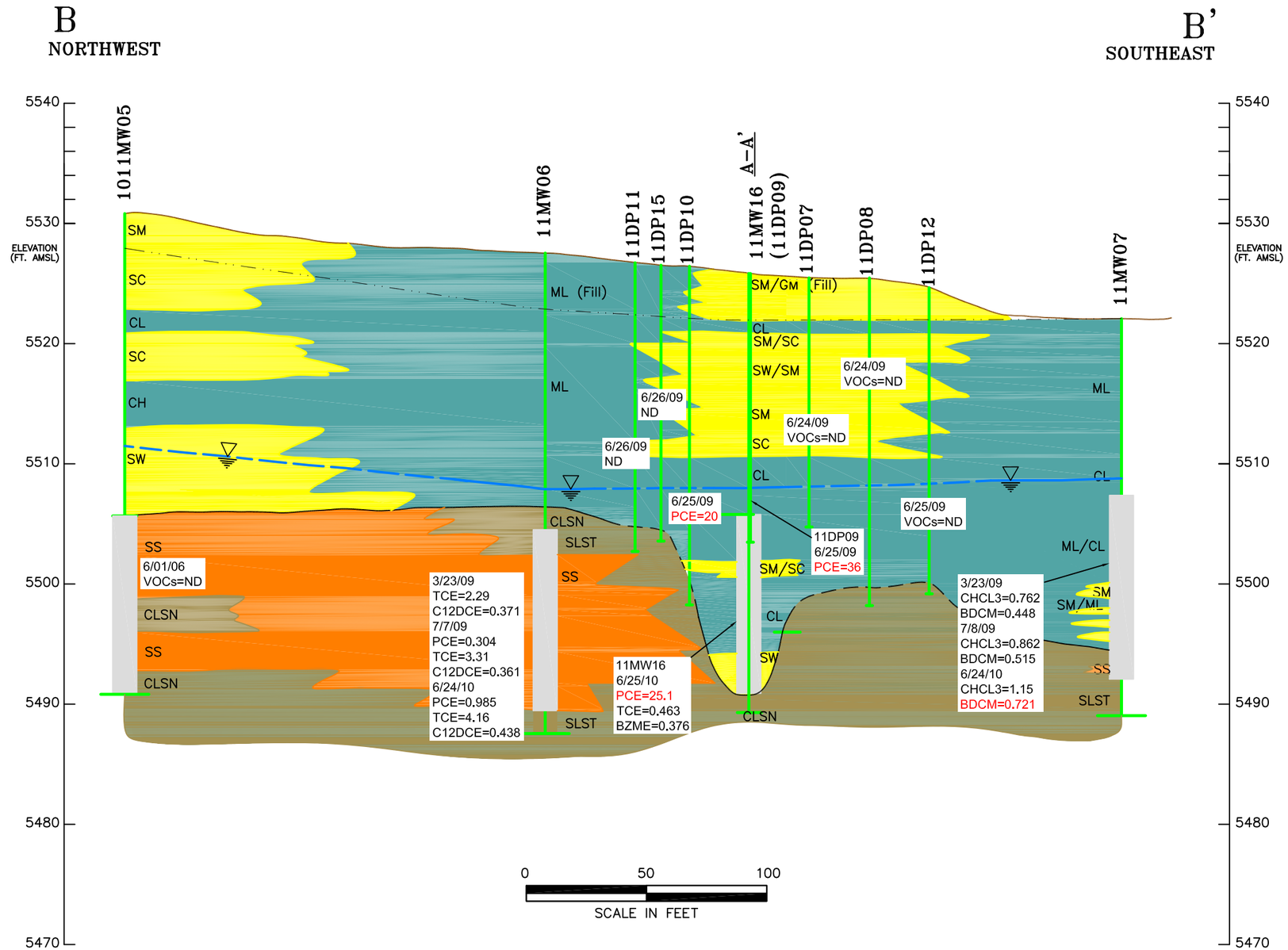
NO LITHOLOGY SAMPLES FOR 11MW14 OR DIRECT-PUSH (DP) LOCATIONS.

ABBREVIATIONS OF SELECT VOCs

CHCL3 = CHLOROFORM
CTCL = CARBON TETRACHLORIDE
C12DCE = cis-1,2-DICHLOROETHENE
MECL2 = METHYLENE CHLORIDE
BDCM = BROMDICHLOROETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
BZ = BENZENE
BZME = TOLUENE
12DCA = 1,2=DICHLOROETHANE

FIGURE 3-2
PCE PLUME
CROSS SECTION A-A'
SHEET 2
SHOWING SELECT VOCs
SITE 11 RI
BUCKLEY AIR FORCE BASE
COLORADO

O:\BUCKLEY\111750-003\XSECT-A-A'-9-10.DWG



EXPLANATION

- = APPROXIMATE BOTTOM OF FILL
- = GROUND SURFACE
- = ALLUVIUM/BEDROCK CONTACT DASHED WHERE INFERRED
- = POTENTIOMETRIC SURFACE (JUNE 2010), DASHED WHERE INFERRED

INTERSECTING CROSS SECTON — A–A'

1011MW07 — LOCATION I.D.

— SCREEN INTERVAL

— TOTAL DEPTH

- = CLAY AND SILT
- = SAND
- = SANDSTONE
- = UNDIFFERENTIATED BEDROCK (DENVER FORMATION SILTSTONE AND CLAYSTONE EXCEPT WHERE NOTED)

CH = CLAY (HIGH PLASTICITY)
CL = CLAY
CLSN = CLAYSTONE
ML = SILT
SC = CLAYEY SAND
SLST = SILTSTONE
SM = SILTY SAND
SP = POORLY GRADED SAND
SS = SANDSTONE
SW = WELL GRADED SAND

TCE=50 = CONCENTRATION OF DETECTED ANALYTE IN MICROGRAMS PER LITER

VOCs=ND = NO SELECT VOLATILE ORGANIC COMPOUNDS (VOCs) DETECTED

3/23/09 = DATE SAMPLED

ANALYTES AND CONCENTRATIONS ARE SHOWN IN "RED" TEXT WHERE CONCENTRATIONS EXCEED COLORADO BASIC STANDARDS FOR GROUNDWATER.

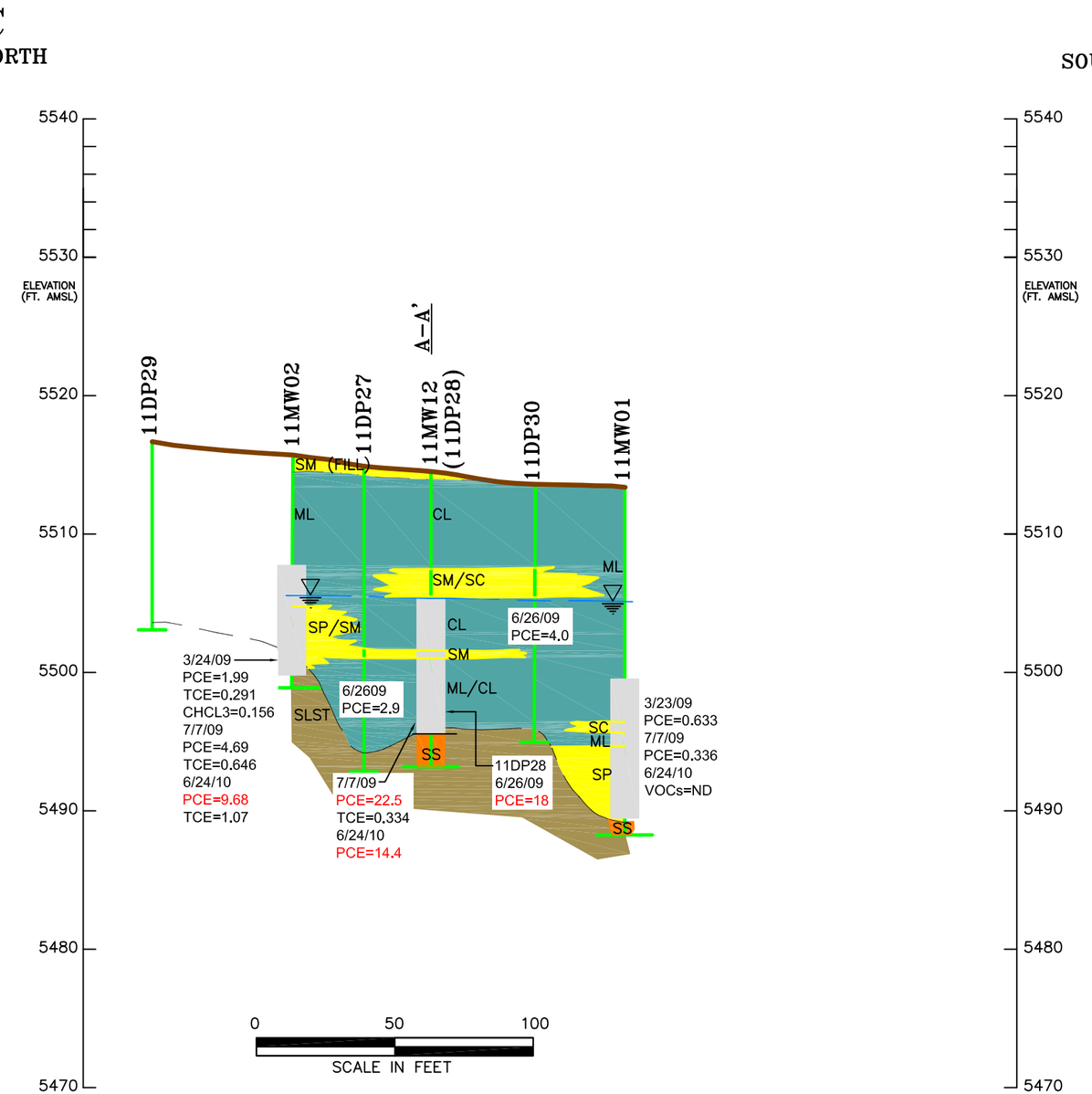
NO LITHOLOGY SAMPLES OR STABLIZED WATER LEVELS FOR DIRECT–PUSH (DP) LOCATIONS.

ABBREVIATIONS OF SELECT VOCs

CHCL3 = CHLOROFORM
CTCL = CARBON TETRACHLORIDE
C12DCE = cis–1,2–DICHLOROETHENE
MECL2 = METHYLENE CHLORIDE
BDCM = BROMODICHLOROMETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
BZ = BENZENE
BZME = TOLUENE
12DCA = 1,2–DICHLOROETHANE

FIGURE 3-3
ON-BASE PCE PLUME
CROSS-GRADIENT
CROSS SECTION B-B'
SHOWING SELECT VOCs
SITE 11 RI
BUCKLEY AIR FORCE BASE
COLORADO

Q:\BUCKLEY\111750–003\XSECT–B–B'–9–10.DWG



EXPLANATION

- = GROUND SURFACE
- = ALLUVIUM/BEDROCK CONTACT
- = POTENTIOMETRIC SURFACE (JUNE 2010), DASHED WHERE INFERRED
- INTERSECTING CROSS SECTON — B-B'
- 1011MW07 — LOCATION I.D.
- SCREEN INTERVAL
- TOTAL DEPTH
- = CLAY AND SILT
- = SAND
- = SANDSTONE
- = UNDIFFERENTIATED BEDROCK (DENVER FORMATION SILTSTONE AND CLAYSTONE EXCEPT WHERE NOTED)

CH = CLAY (HIGH PLASTICITY)
CL = CLAY
CLSN = CLAYSTONE
ML = SILT
SC = CLAYEY SAND
SLST = SILTSTONE
SM = SILTY SAND
SP = POORLY GRADED SAND
SS = SANDSTONE
SW = WELL GRADED SAND

TCE=50 = CONCENTRATION OF DETECTED ANALYTE IN MICROGRAMS PER LITER
VOCs=ND = NO SELECT VOLATILE ORGANIC COMPOUNDS (VOCs) DETECTED
3/23/09 = DATE SAMPLED

ANALYTES AND CONCENTRATIONS ARE SHOWN IN "RED" TEXT WHERE CONCENTRATIONS EXCEED COLORADO BASIC STANDARDS FOR GROUNDWATER.

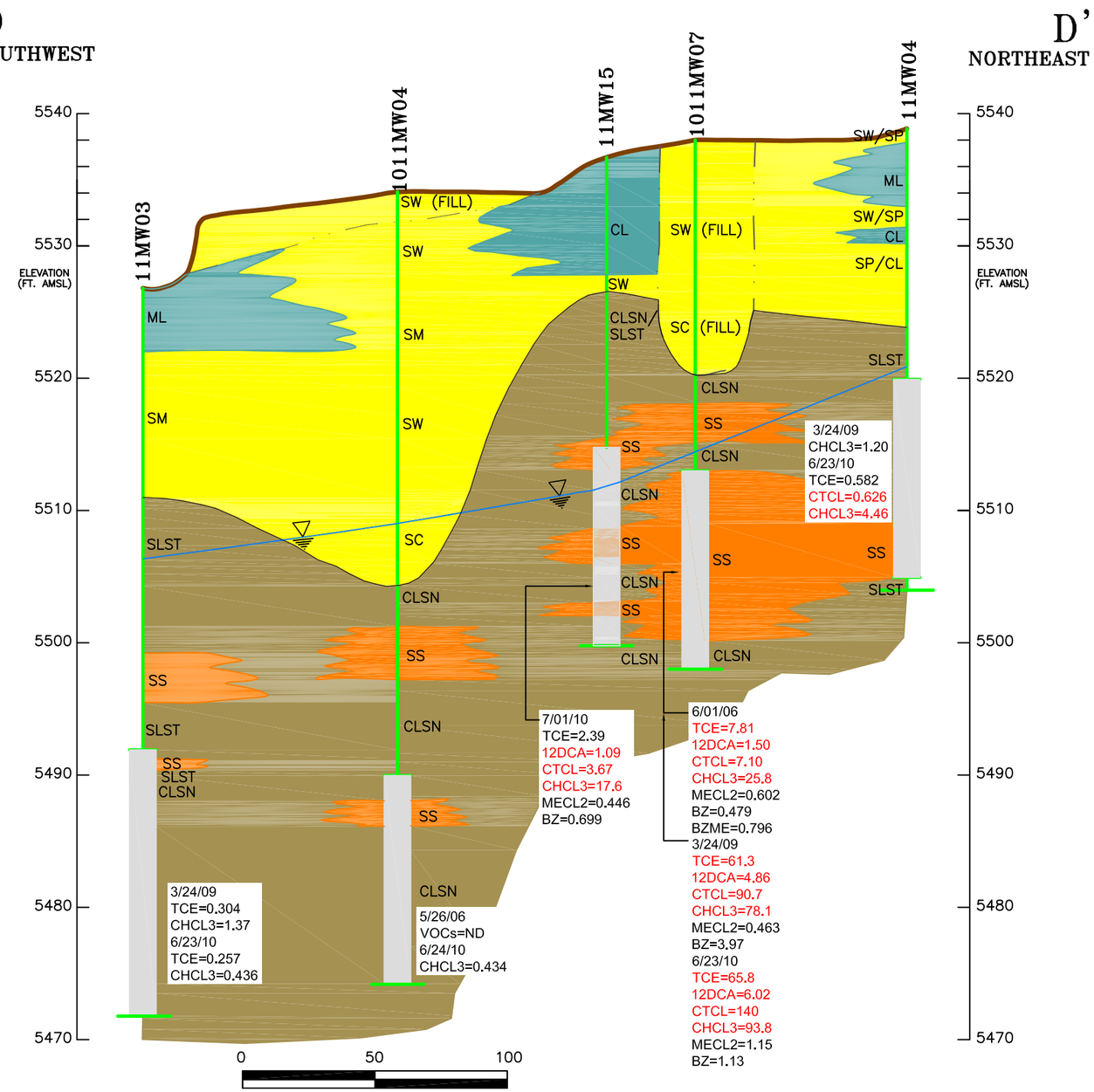
NO LITHOLOGY SAMPLES FOR DIRECT-PUSH (DP) LOCATIONS.

ABBREVIATIONS OF SELECT VOCs

CHCL3 = CHLOROFORM
CTCL = CARBON TETRACHLORIDE
C12DCE = cis-1,2-DICHLOROETHENE
MECL2 = METHYLENE CHLORIDE
BDCL = BROMODICHLOROMETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
BZ = BENZENE
BZME = TOLUENE
12DCA = 1,2-DICHLOROETHANE

FIGURE 3-4
PCE PLUME BASE BOUNDARY
CROSS SECTION C-C'
SHOWING SELECT VOCs
SITE 11 RI
BUCKLEY AIR FORCE BASE
COLORADO

Q:\BUCKLEY\111750-003\XSECT-C-C'-9-10.DWG



EXPLANATION

= GROUND SURFACE

= ALLUVIUM/BEDROCK CONTACT

= POTENTIOMETRIC SURFACE (JUNE 2010)

1011MW07 — LOCATION I.D.

— SCREEN INTERVAL

— TOTAL DEPTH

= CLAY AND SILT

= SAND

= SANDSTONE

= UNDIFFERENTIATED BEDROCK (DENVER FORMATION SILTSTONE AND CLAYSTONE EXCEPT WHERE NOTED)

CH = CLAY (HIGH PLASTICITY)
CL = CLAY
CLSN = CLAYSTONE
ML = SILT
SC = CLAYEY SAND
SLST = SILTSTONE
SM = SILTY SAND
SP = POORLY GRADED SAND
SS = SANDSTONE
SW = WELL GRADED SAND

TCE=50 = CONCENTRATION OF DETECTED ANALYTE IN MICROGRAMS PER LITER

VOCs=ND = NO SELECT VOLATILE ORGANIC COMPOUNDS (VOCs) DETECTED

3/23/09 = DATE SAMPLED

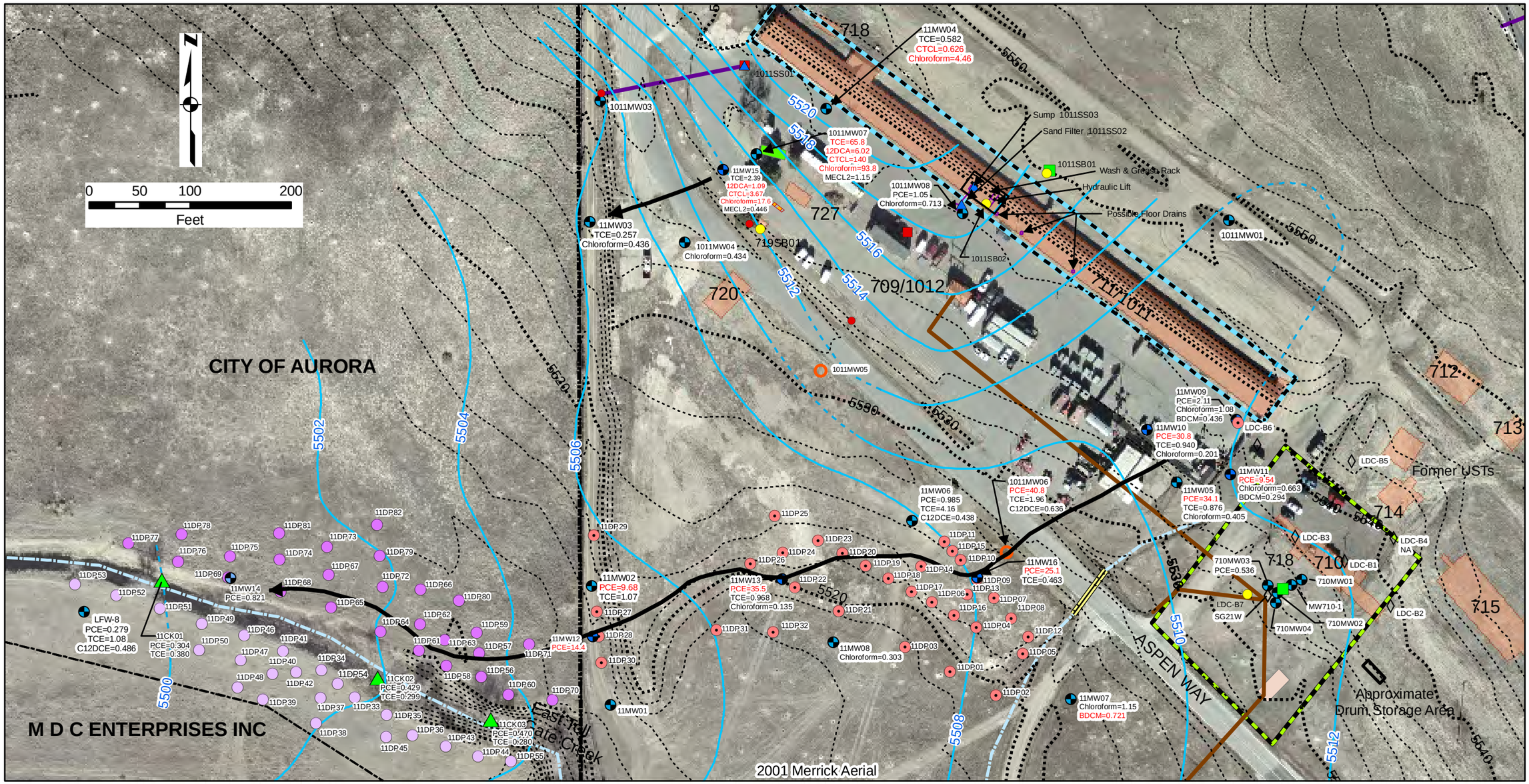
ANALYTES AND CONCENTRATIONS ARE SHOWN IN "RED" TEXT WHERE CONCENTRATIONS EXCEED COLORADO BASIC STANDARDS FOR GROUNDWATER.

ABBREVIATIONS OF SELECT VOCs

CHCL3 = CHLOROFORM
CTCL = CARBON TETRACHLORIDE
C12DCE = cis-1,2-DICHLOROETHENE
MECL2 = METHYLENE CHLORIDE
BDCL = BROMODICHLOROMETHANE
PCE = TETRACHLOROETHENE
TCE = TRICHLOROETHENE
BZ = BENZENE
BZME = TOLUENE
12DCA = 1,2-DICHLOROETHANE

FIGURE 3-5
NORTH PLUME
CROSS SECTION D-D'
SHOWING SELECT VOCs
SITE 11 RI
BUCKLEY AIR FORCE BASE
COLORADO

Q:\BUCKLEY\111750-003\XSECT-D-D'.DWG



Legend

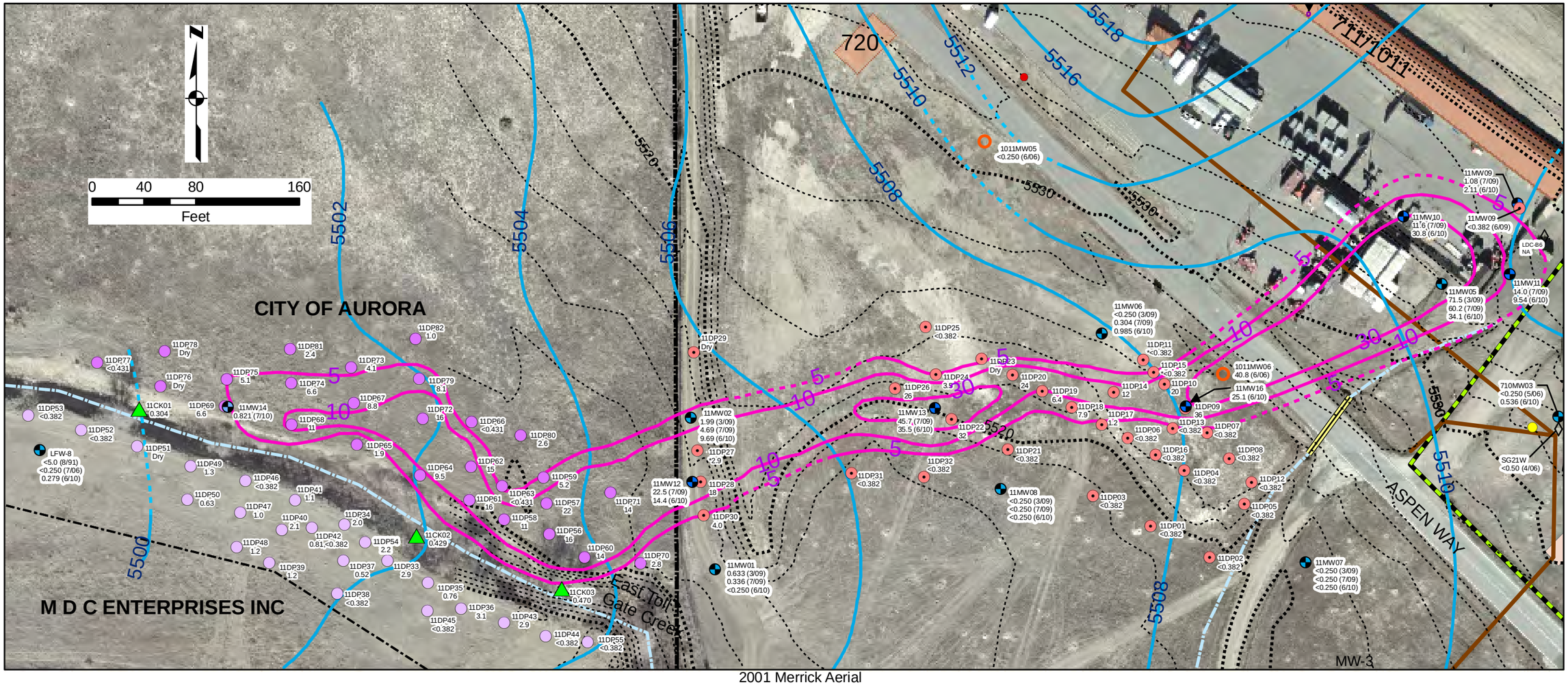
- Monitoring Well
- Groundwater Grab Sampling Location (6/09)
- Groundwater Grab Sampling Location (5/10)
- Groundwater Grab Sampling Location (2/10)
- Abandoned Monitoring Well
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Abandoned Temporary Well
- Catch Basin
- Underground Storage Tank
- Surface Water and Sediment Sample
- Potentiometric Contour (June 10) Dashed Where Inferred
- Topographic Contour
- Storm Sewer Culvert
- Storm Sewer Line
- Storm Sewer Open Drainage
- Wastewater Line
- Base Boundary
- Pump Island
- Parcel Boundary (Arapahoe County on-line GIS 7/09)
- Groundwater Flow
- Firing Tunnel Investigation Area
- LNAPL Investigation Area
- Septic Tank
- Former Structure

Notes:

1) Concentrations are in micrograms per liter.
2) Analytes and concentrations are shown in "red" text where concentrations exceed CBSGs.
3) Only VOCs exceeding CBSGs or their degradation products (e.g., C12DCE, MECL2) in one or more Site 11 wells are shown.
4) Most recent data are shown.
5) Refer to Figures 3-7 and 3-8 for groundwater grab sample data.
12DCA - 1,2-dichloroethane
BDCM - bromodichloromethane
C12DCE - cis-1,2-dichloroethane
CBSG - Colorado Basic Standard for Groundwater (Reg. 41)
CTCL - carbon tetrachloride
MECL2 - methylene chloride
NA - not analyzed
PCE - tetrachloroethene
TCE - trichloroethene
VOC - volatile organic compound

Figure 3-6
Detections of VOCs Above Groundwater Standards in Monitoring Wells and Surface Water
Site 11 RI
Buckley Air Force Base

Detections_VOC_09-10.mxd



2001 Merrick Aerial

Legend

- Base Boundary
- Storm Sewer Open Drainage
- Topographic Contour
- Potentiometric Contour (June 10, dashed where inferred)
- Parcel Boundary
- Wastewater Line
- Storm Sewer Culvert
- Septic Tank
- Former Structure
- LNAPL Investigation Area
- 5 PCE Isoconcentration Contour (June-July 2010), dashed where inferred
- Groundwater Grab Sampling Location with PCE Concentration (5/10)
- Groundwater Grab Sampling Location with PCE Concentration (2/10)
- Groundwater Grab Sampling Location with PCE Concentration (6/09)
- Surface Water Sample Location with PCE Concentration (2/10)
- Monitoring Well with PCE Concentration and Sample Dates
- * Sample obtained from location that was initially dry; potential dilution by rainwater.
- Abandonded Monitoring Well
- Pipe Discharge
- Soil Boring (2005-2006)
- Abandonded Temporary Well

Notes:

NA - Not Analyzed

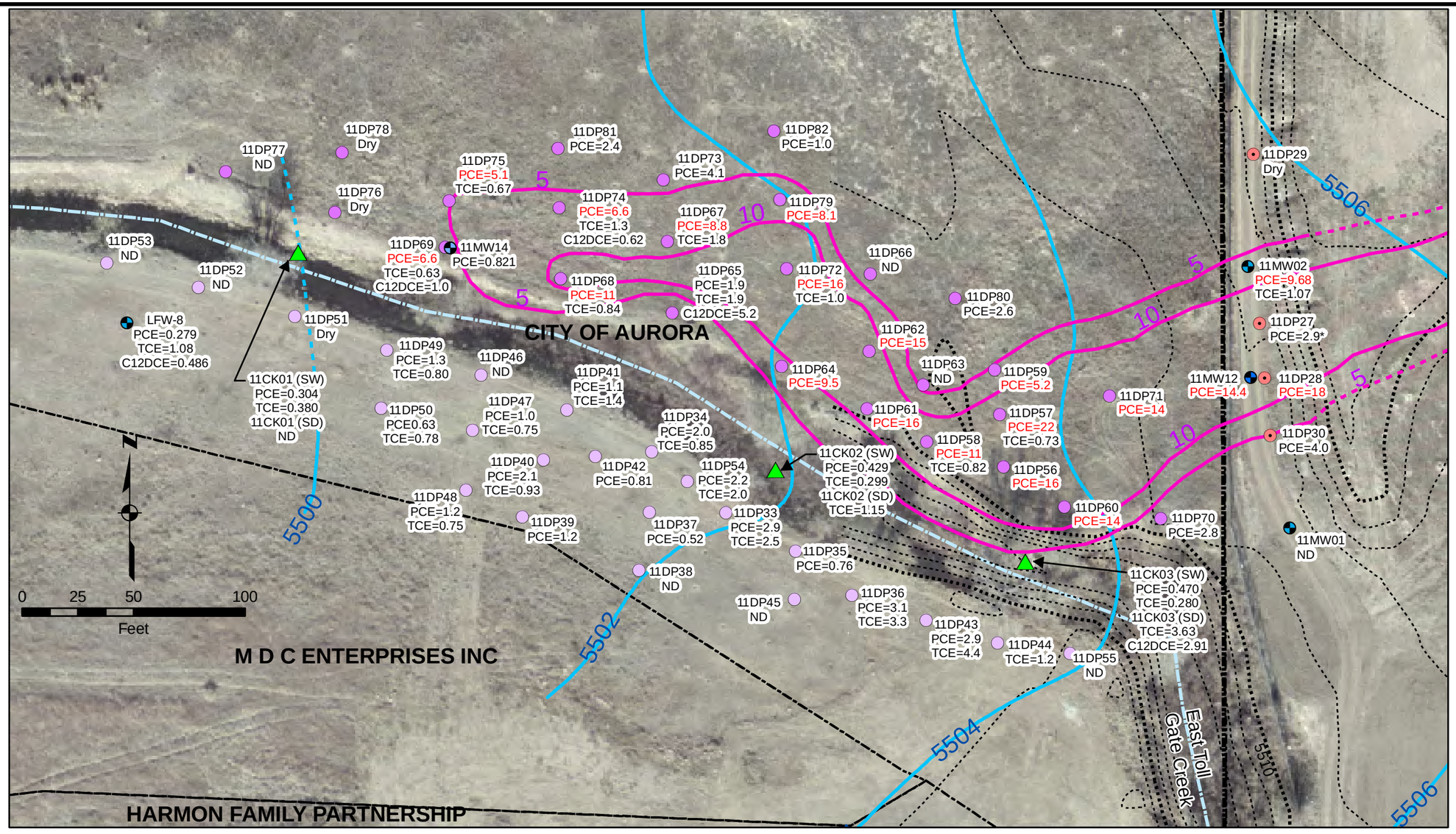
PCE - Tetrachloroethene

PCE concentrations are in micrograms per liter.

Parcel owner information from Arapahoe County on-line GIS (7/09).

Figure 3-7
PCE Plume and Concentrations in Groundwater and Surface Water Samples
Site 11 RI
Buckley Air Force Base

GIS\BUCKLEY\PCE_Plume_Conc_09-10.mxd



2001 Merrick Aerial

Legend

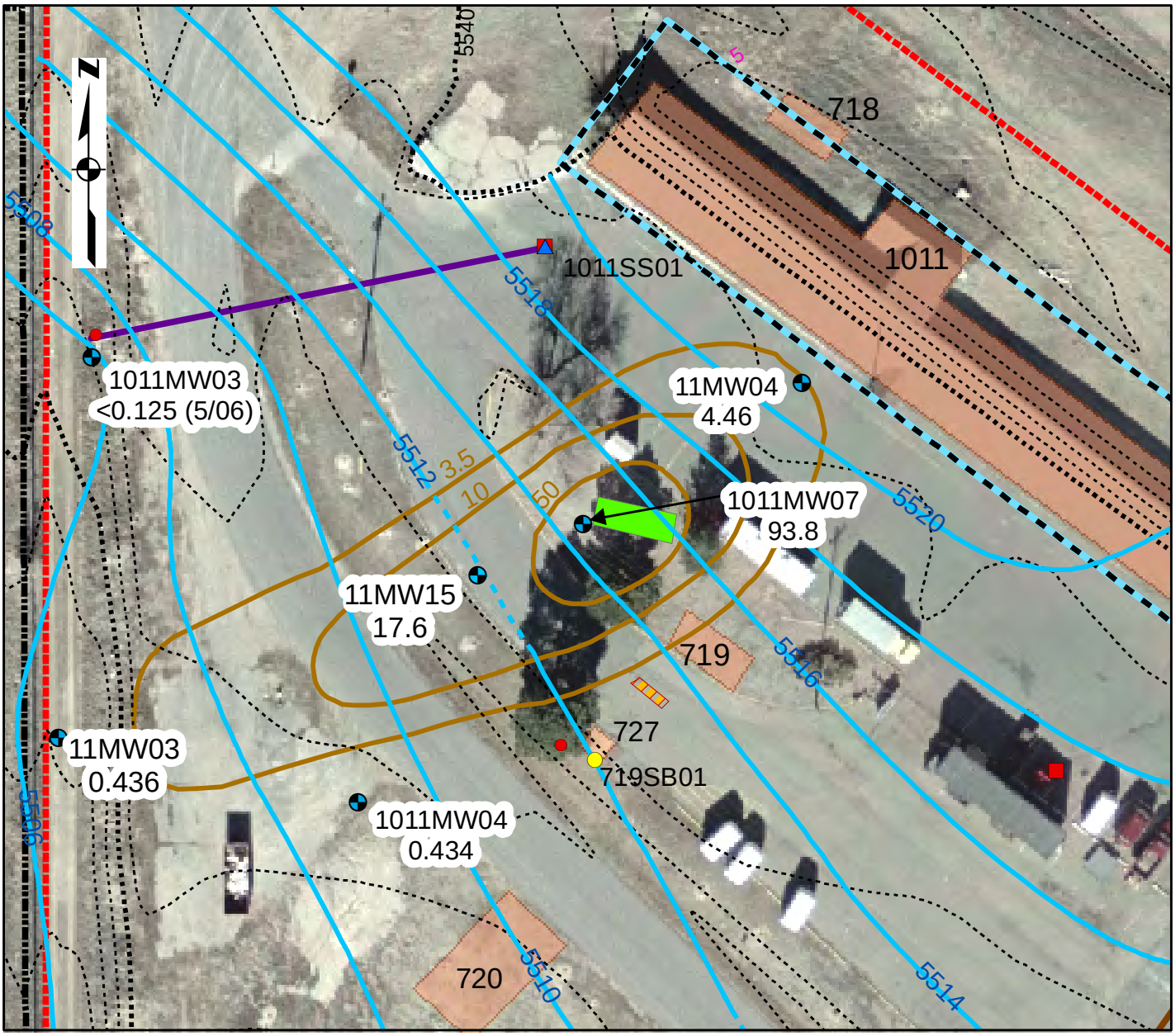
- Base Boundary
- Storm Sewer Open Drainage
- Topographic Contour
- Potentiometric Contour (June 10) Dashed where inferred
- Parcel Boundary
- 5 PCE Isoconcentration Contour (June-July 2010), dashed where inferred
- Groundwater Grab Sampling Location (5/10)
- Groundwater Grab Sampling Location (2/10)
- Groundwater Grab Sampling Location (6/09)
- Surface Water and Sediment Sample Location (2/10)
- Monitoring Well
- * Sample obtained from location that was initially dry; potential dilution by rainwater.

Notes:

1) Concentrations are in parts per billion. For wells, most recent data (6/10 and 7/10) are shown.
2) Analytes and concentrations are shown in "red" text where concentrations exceed CBSGs.
3) Parcel owner information from Arapahoe County on-line GIS (7/09).
NA - Not Analyzed
ND - Not Detected
C12DCE - cis-1,2-Dichloroethene
CBSG - Colorado Basic Standard for Groundwater (Reg. 41)
PCE - Tetrachloroethene
SD - Sediment
SW - Surface Water
TCE - Trichloroethene

Figure 3-8
Detections of PCE and Degradation Products in Off-Base Samples
Site 11 RI
Buckley Air Force Base

GIS\BUCKLEY\PCE_Degradation-09-10.mxd



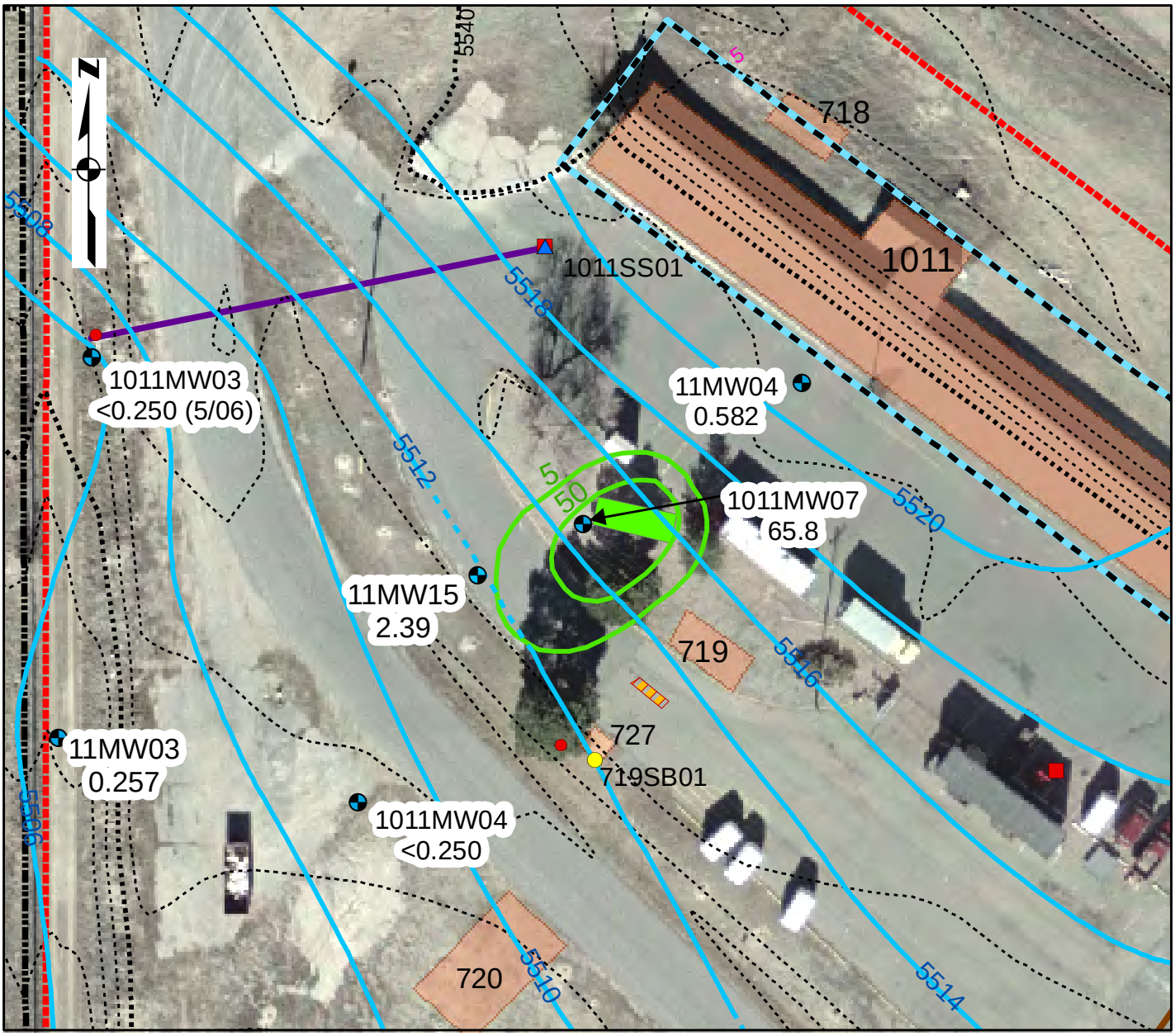
Legend

- Base Boundary
- Chloroform Concentration (micrograms per liter)
- Potentiometric Contour (June 10), dashed where inferred
- Storm Sewer Line
- Existing Monitoring Well with Chloroform Concentration (micrograms per liter)
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Catch Basin
- Underground Storage Tank
- Former Structure
- Pump Island

0 25 50 100
Feet

Figure 3-9
June 2010 Chloroform Distribution
North Plume Area
Site 11 RI
Buckley Air Force Base

chloroform-6-10.mxd



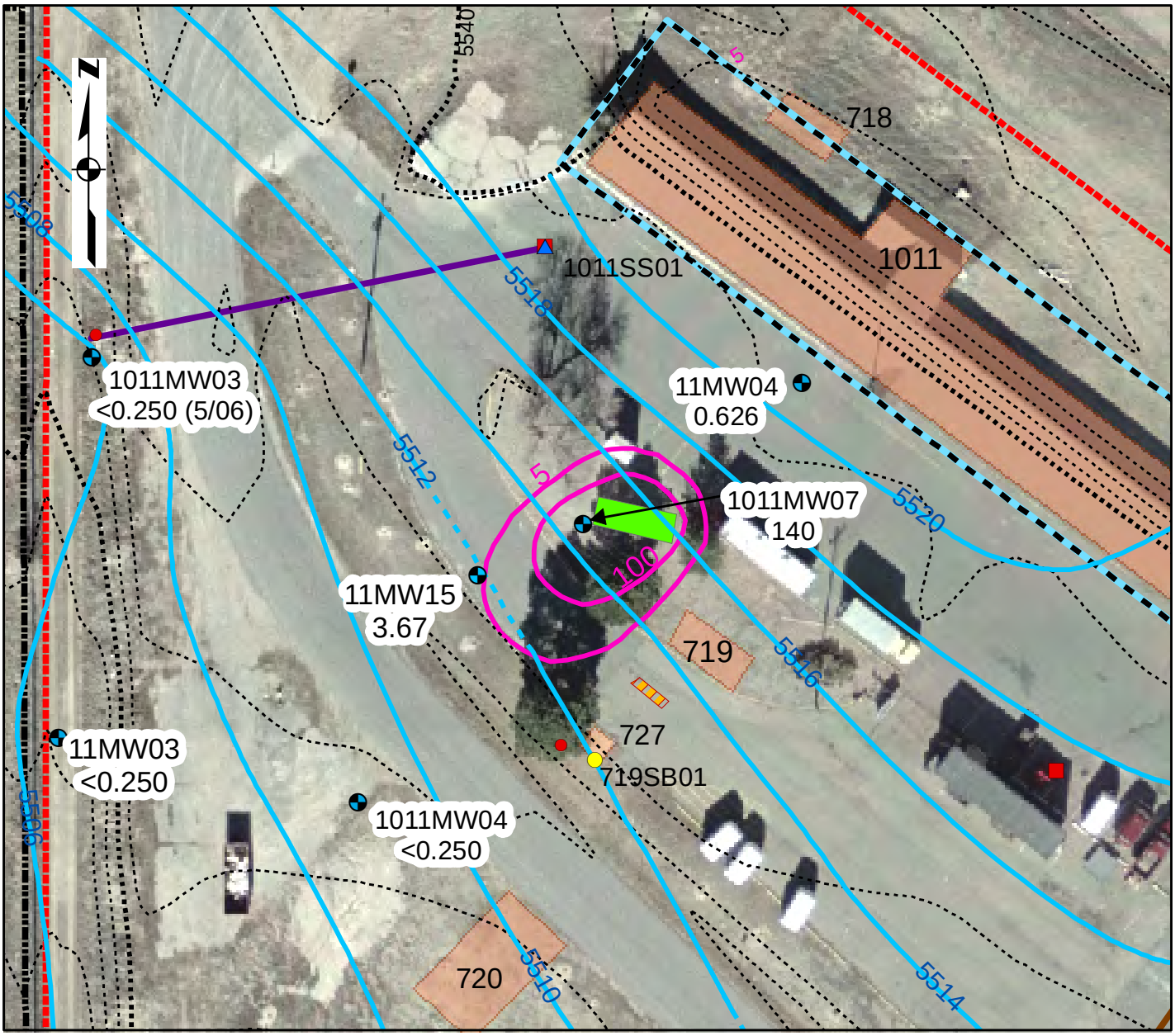
Legend

- Base Boundary
- TCE Concentration (micrograms per liter)
- Potentiometric Contour (June 10), dashed where inferred
- Storm Sewer Line
- Existing Monitoring Well with TCE Concentration (micrograms per liter)
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Catch Basin
- Underground Storage Tank
- Former Structure
- Pump Island

0 25 50 100
Feet

Figure 3-10
June 2010 TCE Distribution
North Plume Area
Site 11 RI
Buckley Air Force Base

TCE-6-10.mxd



Legend

- Base Boundary
- Carbon Tetrachloride Concentration (micrograms per liter)
- Potentiometric Contour (June 10), dashed where inferred
- Storm Sewer Line
- Existing Monitoring Well with Carbon Tetrachloride Concentration (micrograms per liter)
- Pipe Discharge
- Soil Boring (2005-2006)
- Sediment Sample
- Catch Basin
- Underground Storage Tank
- Former Structure
- Pump Island

0 25 50 100
Feet

Figure 3-11
June 2010 Carbon Tetrachloride Distribution North Plume Area
Site 11 RI
Buckley Air Force Base

Carbon_Tet-6-10.mxd

Figure 4-1
Downgradient Concentration Trend for Site 11 PCE Plume
June/July 2010
Buckley Air Force Base, Colorado

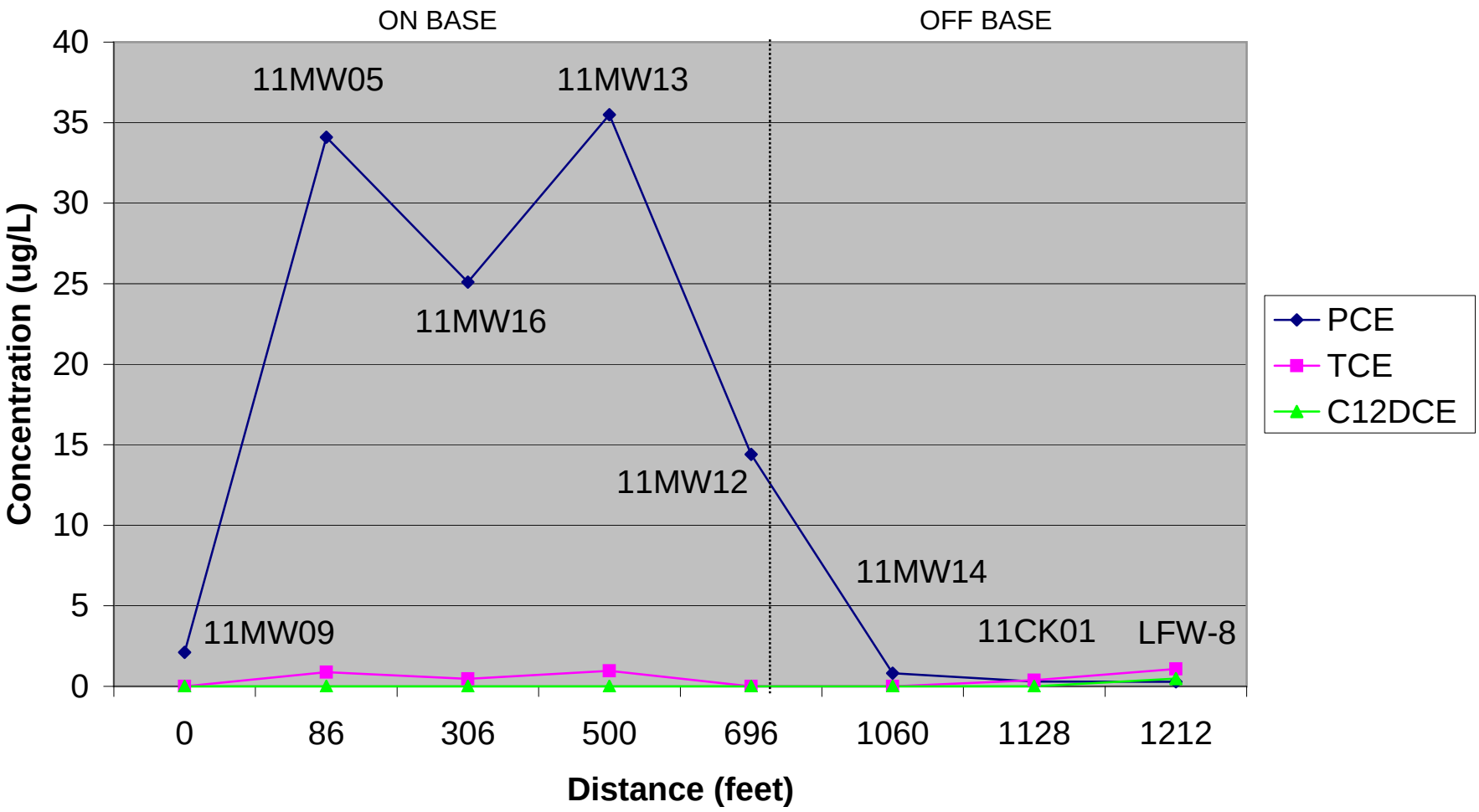
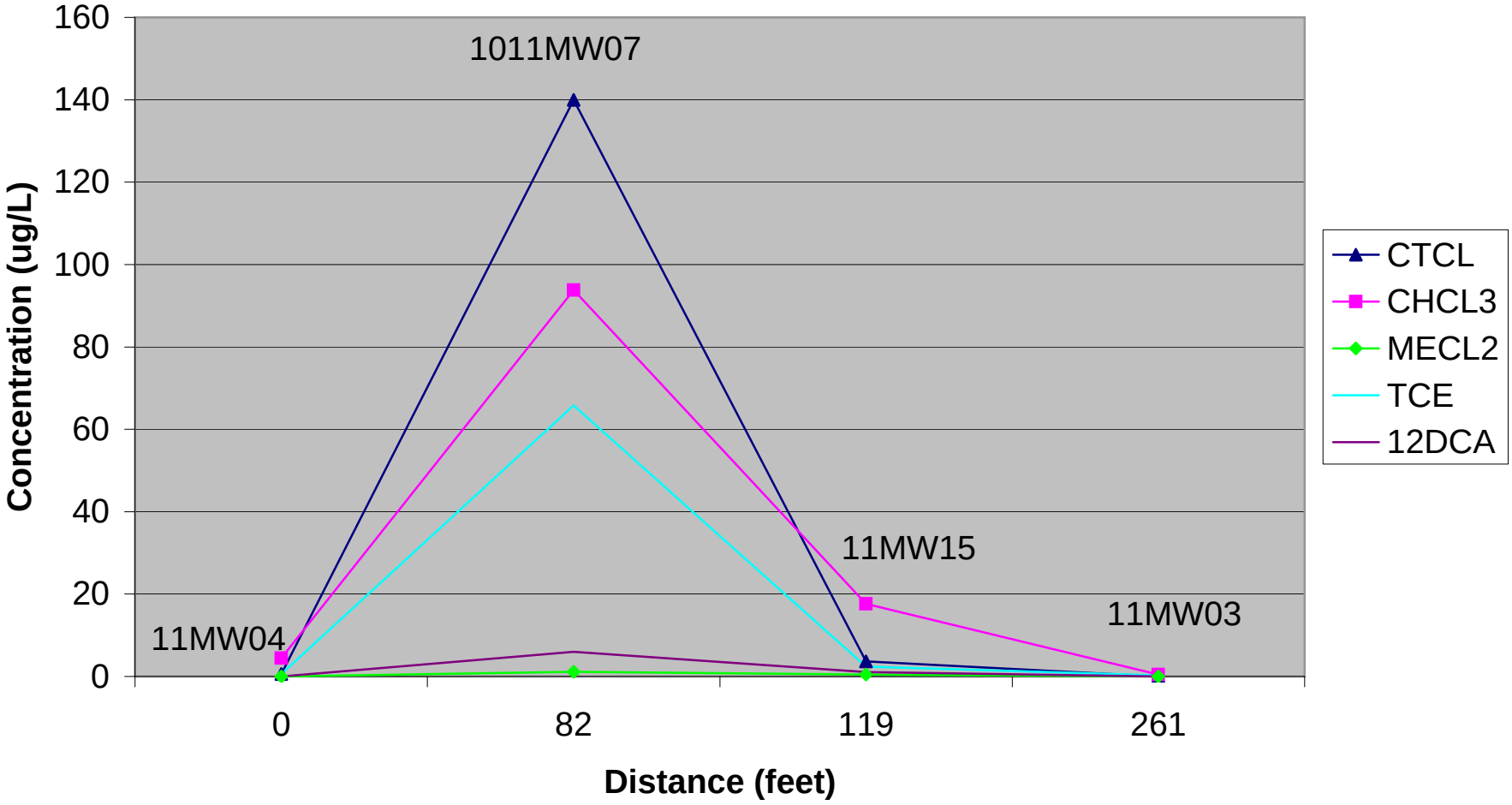
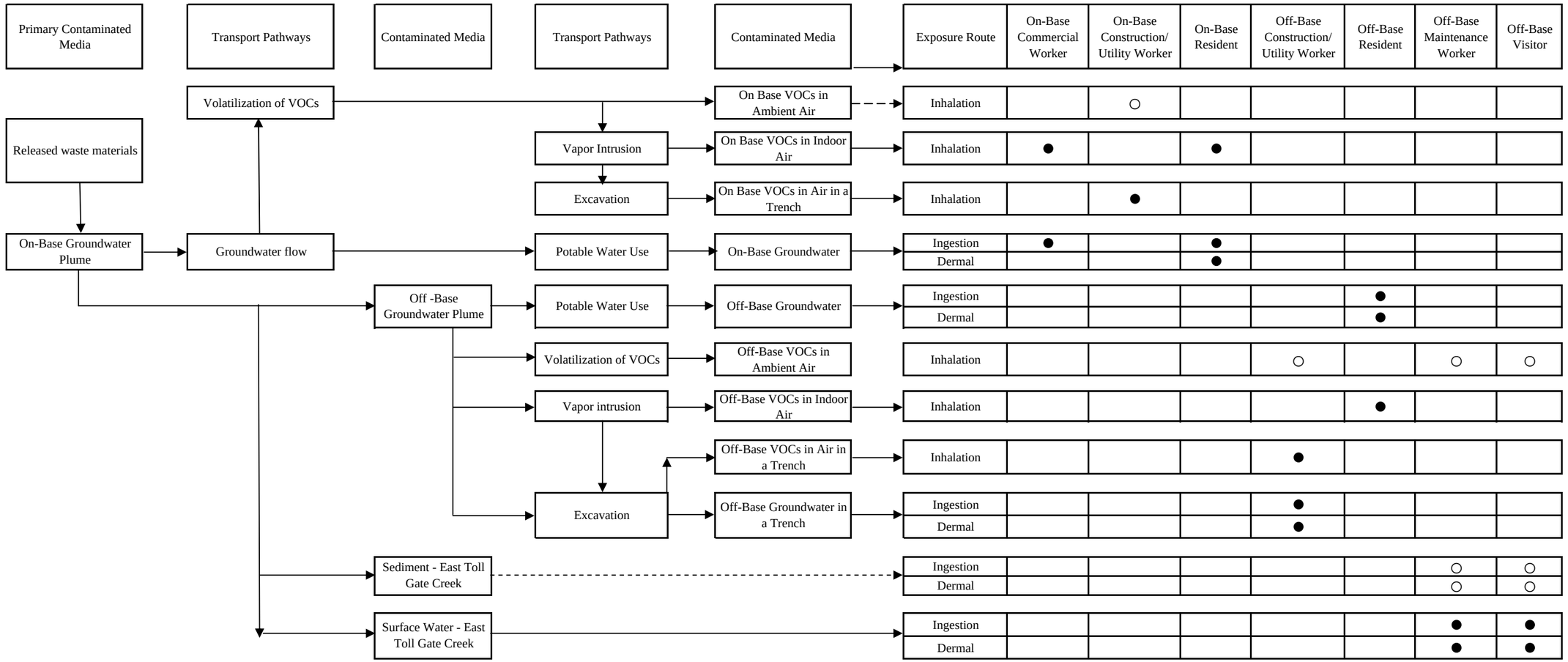


Figure 4-2
Downgradient Concentration Trend for Site 11 North Plume
June/July 2010
Buckley Air Force Base, Colorado





Notes:

(1) Hypothetical future indoor commercial worker assumed to work in a building located directly above the area of maximum groundwater contamination on base. There are no plans to use groundwater on base in Site 11. However, a hypothetical commercial worker will be evaluated for potable water use of groundwater in the source area.

(2) Future construction is not planned on Site 11. However, a hypothetical future construction/utility worker will be evaluated in the source area on the base. On base groundwater is too deep to be encountered during typical excavation activities.

(3) Future residential use of Site 11 is not planned. However, a hypothetical future resident will be evaluated in the source area on the base. There are no plans to use groundwater on base in Site 11. However, a hypothetical resident will be evaluated for domestic use of groundwater in the source area.

(4) Future construction/utility worker assumed to work in a trench or foundation located directly above the area of maximum groundwater contamination off base.

(5) There are no plans for building off base in the area of the Off-Base PCE Plume. However, a hypothetical off-base resident exposed to indoor air will be evaluated in the area of maximum groundwater contamination off base. There are no plans to use off-base groundwater. However, a hypothetical off-base resident will be evaluated for ingestion of groundwater from the area of maximum groundwater contamination off base.

(6) Current/future maintenance worker assumed to visit off-base open area and East Toll Gate Creek infrequently for maintenance activities.

(7) Current/future visitors (youths) assumed to visit off-base open area and East Toll Gate Creek infrequently for recreational activities.

VOCs - volatile organic compounds

LEGEND

	Pathway Not Complete, No Evaluation Necessary
○	Pathway Is or May Be Complete, However, Risk Is Likely Low; Qualitative Evaluation Only
●	Pathway Is Complete and May Be Significant; Quantitative Evaluation
- - - - ▶	Transport pathway is minor or incomplete

Figure 5-1
Human Health Conceptual Site Model For Site 11

SITE 11 REMEDIAL INVESTIGATION REPORT
BUCKLEY AIR FORCE BASE - COLORADO

Table 1-1
Summary of Buildings/Structures
Site 11 (Building 1011 Area)
Buckley Air Force Base, Colorado

Building/ Structure	Use		Construction Date[a]	Removal Date[a]
	Original	Other		
709 (1012)	Latrine	Storage (flammable)	Before 1959[b]	2005
710	Refueling Truck Maintenance		1961	1994
711 (1011)	Synchronization Shed	Motor Pool, CE Shops	1942	2005
712	Latrine	Storage	1942	1994
713	Vault (machine gun)	Storage (paint, flammable)	1942	1996
714	Steam Heating Plant		1942	1996
715	Stoppage and Jam	Storage	1942	1980s/1990s
716	Stoppage and Jam	Storage	1942	1980s/1990s
717	Stoppage and Jam	Storage	1942	1980s/1990s
718	Compressed Air		1942[c]	1972
718	Vehicle Operations		1974	1994
719	Gasoline Station		1949	1997
720	Heavy Equipment/Repair	Heavy Equipment/Storage	1955	1996
727	Vehicle Ready Fuel Tank		Unknown[d]	Unknown[d]

[a]Construction and removal dates are based on Buckley AFB records and aerial photographs
[b]Buckley records indicate it was constructed in 1967, but was evident on a 1959 photograph
[c]Base records indicate it was constructed in 1942 and is evident on 1955 and 1961 drawings, but not seen on aerial photgraphs until 1963
[d]Identified on a 1959 list of structures

CE - Civil Engineering

Table 1-2
Historical Detections of VOCs in Groundwater
at Site 11 and Adjacent Sites
Buckley Air Force Base, Colorado

Sampling Location/ Well ID	Sample Date	Screened Interval (ft bgs)	Aquifer	Volatile Organic Compounds (ug/L)																			
				PCE	TCE	1,2-DCE (c), (t), or nonspecific	1,2-DCA	Chloro-form	Carbon Tetra-chloride	Methylene Chloride	Hexachloro-butadiene	Acetone	Benzene	Toluene	p- (or 4-) Isopropyl toluene	1,2,3-Trichloro-benzene	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	n-Butyl-benzene	sec-Butyl-benzene	tert-Butyl-benzene	o- (or total) Xylenes	Naphtha-lene
Regulatory Standard (ug/L):				5[M]	5[M]	70[M](c), 100[M](t)	**0.38** - 5[M]	**3.5**	**0.27 - 5[M]**	4.7 - 5[M]	**0.45**	None	5[M]	560 - 1000[M]	None	None	None	None	None	None	None	1,400-10,000[M]	140
Upgradient/Background																							
1011MW01	5/26/06	45 - 60	D	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 M	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	= 3.36 F	< 0.125 L	= 0.354 F	= 1.57 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L
AOC-Wide																							
1011MW02	5/26/06	45 - 60	D	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	= 0.135 F	< 0.250 L	< 0.250 L	< 0.250 L	< 2.50 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L
1011MW03	5/26/06	45 - 60	D	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	**= 0.507[a] F**	< 2.50 L	< 0.125 L	< 0.250 L	< 0.250 L	= 0.146[a] F	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L
1011MW04	5/26/06	45 - 60	D	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	= 8.50 F	< 0.125 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L
1011MW04D				< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	= 6.49 F	< 0.125 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L
1011MW05	6/1/06	25 - 40	A/D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
1011MW06	6/1/06	20 - 30	A/D	**= 40.8**	= 1.96	= 0.636 F	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
Building 719 UST																							
1011MW07	6/1/06	25 - 40	D	< 0.250	**= 7.81**	< 0.250	**= 1.50**	**= 25.8**	**= 7.10**	= 0.602 F	< 0.250	= 4.05 F	= 0.479	= 0.796 F	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
Hydraulic Lift/Sump/Sand Filter																							
1011MW08	6/1/06	20 - 35	D	= 1.05	< 0.250	< 0.250	< 0.250	= 0.713	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
Building 710 LNAPL Area																							
710MW01	5/23/06	32 - 42	D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	= 0.276 F	= 6.44 F	= 0.251 F	< 0.250	< 0.250	= 0.166 F	< 0.250	= 1.00	= 0.448 F	< 0.250	< 0.250	= 0.465 F	= 0.268 F
710MW01D				< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	= 7.10 F	= 0.279 F	= 0.280	< 0.250	< 0.125	< 0.250	= 0.720	= 0.259 F	< 0.250	< 0.250	= 0.485[b] F	< 0.200
710MW02	5/23/06	26 - 36	D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
710MW03	5/23/06	26 - 36	D	< 0.250	< 0.250	< 0.250	< 0.250	= 0.144 F	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
710MW04	5/23/06	30 - 40	D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	= 0.186 F	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
SG21W[c]	4/19/06	38 - 43	D	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 5	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
MW710-1[d]	2/20/92	30 - 45	D	< 5	< 5	< 5	< 5	< 5	< 5	< 5	NA	< 100	= 2 J	= 7	NA	NA	NA	NA	NA	NA	NA	= 55 (total)	NA
MW710-1[c]	3/23/06			< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA	< 0.50	< 0.50	= 3.84	= 6.65	= 0.73	= 6.65	= 5.58	= 0.96	= 0.76	< 0.50	< 0.50
LDC-B1[c]	3/23/06	25 - 30	D	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
LDC-B2[c]	3/23/06	25 - 30	D	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA	< 0.50	= 0.55	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
LDC-B3[c]	3/23/06	25 - 30	D	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	NA	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
LDC-B5[e]	2/23/05	25 - 30	D	< 0.046	< 0.031	< 0.039	< 0.018	< 0.023	< 0.033	< 0.089	< 0.146	< 0.23	< 0.017	< 0.016	< 0.022	< 0.139	< 0.024	< 0.032	< 0.048	< 0.019	< 0.017	< 0.035	< 0.127
Site 2 and Nearby Site 3 Wells																							
2WPMW01	1/11/05	17.5 - 27.5	A/D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
MW-3	11/6/84	10 - 40	A/D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-4	11/6/84	8 - 33	A/D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	10-12/88			NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 100	< 5.0	< 5.0	NA	NA	NA	NA	NA	NA	NA	< 5	< 10
	8/16/91			< 5.0	= 1 J	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 10	= 4 J	= 2 J	NA	NA	NA	NA	NA	NA	NA	< 5	< 9
LFW-8	12/88	8.2 - 18	A/D	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 100	< 5.0	< 5.0	NA	NA	NA	NA	NA	NA	NA	< 5	< 10
	8/22/91			< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 10	< 5.0	< 5.0	NA	NA	NA	NA	NA	NA	NA	< 5	< 9
	7/18/06			< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200
LFW-19	6/16/98	14 - 24	A/D	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 2.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	12/15/98			< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 2.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	6/30/99			< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 2.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	9/18/01			< 0.087	= 0.1 F	< 0.145	< 0.067	= 0.26 F	< 0.06	< 0.06	< 0.102	NA	< 0.032	< 0.015	< 0.029	< 0.063	< 0.014	< 0.018	< 0.037	< 0.026	< 0.024	< 0.013	< 0.05
	3/13/02			< 0.04	= 0.1 F	< 0.02	< 0.012	= 0.16 F	< 0.019	< 0.02	< 0.085	NA	< 0.015	< 0.015	< 0.032	< 0.074	< 0.039	< 0.037	< 0.072	< 0.028	< 0.026	< 0.028	< 0.06
	7/18/06			= 2.68	**= 5.07**	= 0.419 F	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 2.50	< 0.125	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200

Notes:

Regulatory standards are the Colorado Basic Standards for Groundwater (CBSG), Regulation 41 (5/31/08). CBSGs that are the drinking water MCL are identified with an "M". The first number in a range is a health-based value, and may not be applicable for releases before 9/14/04.
Bold indicates analytical result is at or exceeds regulatory standard and which standard(s) is exceeded.

Footnotes:

[a]The laboratory indicated the detections of hexachlorobutadiene and 1,2,3-trichlorobenzene in 1011MW03 (between the MDL and RL) may be attributed to carry-over contamination from a previous, unrelated sample.
[b]A low concentration of m,p-xylene was also reported, between the MDL and RL, at 0.616 F ug/L.
[c]Sample data collected for baseline information purposes - semiqualitative and semiquantitative results.
[d]Ethylbenzene was also detected, at 13 ug/L.
[e]A low concentration of chloromethane, between the MDL and PQL, was reported, at 0.3 F ug/L.

Qualifiers:

= - detected
< - not detected
F - analyte positively identified, but value is below the RL
L - sample analyzed within 1 to 1.5 times the holding time
M - a matix effect was present
J - analyte positively identified; the quantitation is an estimation

Abbreviations:

A - Alluvial aquifer
(c) - cis
D - Denver Formation aquifer
DCA - dichloroethane
DCE - dichloroethene
ft bgs - feet below ground surface
MCL - maximum contaminant level
MDL - method detection limit
NA - not analyzed
PCE - tetrachloroethene
PQL - practical quantitation limit
RL - reporting limit
(t) - trans
TCE - trichloroethene
ug/L - micrograms per liter
UST - underground storage tank

Table 2-1
Monitoring Well Construction Summary
Site 11 RI
Buckley Air Force Base, Colorado

Well ID	Aquifer	Date Installed	Interpreted Depth to Bedrock (ft bgs)	Approximate Screen Interval[a] (ft bgs)	Total Depth Reached (ft bgs)
Initial RI					
11MW01	Alluvium	3/10/09	24.2	14 - 24	25.2
11MW02	Alluvium/Denver	3/10/09	14.5	8 – 16	17
11MW03	Denver	3/11/09	16	35 – 55	55
11MW04	Denver	3/13/09	15	19 – 34	35
11MW05	Denver	3/17/09	15	24 - 39	55
11MW06	Denver	3/12/09	21	23 - 38	40
11MW07	Alluvium/Denver	3/16/09	28.6	15 – 30	33
11MW08	Alluvium	3/16/09	27.7	13 – 28	29
Second Phase RI					
11MW09	Denver	6/29/09	10	27 – 42	43
11MW10	Denver	6/30/09	7	31 – 46	50
11MW11	Denver	7/1/09	11	30 – 45	45
11MW12	Alluvium/Denver	6/29/09	18.4	9 – 19	21.5
11MW13	Alluvium	6/30/09	31.2	16 – 31	32
Third Phase RI					
11MW14[b]	Alluvium/Denver[b]	5/27/10	17[b]	8.2 - 18.2	19
11MW15[c]	Denver	6/21/10	10.5	22.5 – 37.5	37.5
11MW16[c]	Alluvium	6/22/10	35	20 - 35	36.5

ft bgs – feet below ground surface

[a] – All wells constructed of 2-inch diameter polyvinyl chloride (PVC) casing and screen.
[b] – Well installed using direct-push method north of East Toll Gate Creek; no lithology samples collected.
[c] – Well installed under USACE-funded contract.

Table 2-2
Sample Analysis Summary
Site 11 RI
Buckley Air Force Base, Colorado

Matrix	Analyte Group	Method	Samples (Field)	Ambient Blanks (QC)	Field Duplicates (QC)	Matrix Spikes (QC)	Total Samples
Initial Phase of RI - Off-Site Analysis (March 2009)							
Ground water	VOCs	SW8260B	9	1	1	2	13
	1,4-Dioxane	SW8270C	1	0	0	0	1
Second Phase of RI – Off-Site Analysis (July 2009)							
Ground water	VOCs	SW8260B	11	1	1	2	15
	1,4-Dioxane	SW8270C	1[a]	0	0	2	3
Second Phase of RI – Mobile Lab Analysis (June-July 2009)							
Ground water	VOCs[b]	SW8260B[b]	32[c]	0	1	0	33
Third Phase of RI – Off-Site Analysis (June-July 2010)							
Ground water	VOCs	SW8260B	20	1	2	2	25
Surface Water	VOCs	SW8260B	3	0	0	0	3
Sediment	VOCs	SW8260B	3	0	0	0	3
Third Phase of RI – Mobile Lab Analysis (Feb & May 2010)							
Ground water	VOCs[b]	SW8260B[b]	48	0	1	0	49
Surface Water	VOCs[b]	SW8260B[b]	3	0	0	0	3
Sediment	VOCs[b]	SW8260B[b]	3	0	0	0	3
Investigation-Derived Waste (all phases)							
Soil	VOCs	SW8260B	3	0	0	0	3
Soil	Metals[d]	SW6010B/ 7471A[d]	3	0	0	0	3
Soil	Corrosivity	9045D	3	0	0	0	3
Soil	Ignitability	1010	3	0	0	0	3
Soil	Reactivity	SW7.33/ 7.34	1	0	0	0	1

[a]Sample collected separately in August 2009
[b]Only tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, vinyl chloride, and chloroform
[c]Includes grab samples from well 11MW05 and the borehole for well 11MW09
[d]Only arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury

MS – matrix spike
MSD – matrix spike duplicate
QC – quality control
SW – solid waste
VOC – volatile organic compound

Table 2-3
Summary of Monitoring Well Sampling and Water-Level Measurements
Site 11 RI
Buckley Air Force Base, Colorado

Well Number	Screened Interval (ft bgs)	Approx. Depth to Bedrock (ft bgs)	Aquifer	Water-Level Measurement Rounds				Monitoring Well Sampling		
				3/5/2009	4/8/2009	7/10/2009	6/23/2010	Mar-09	Jul-09	June-July 2010
Wells Installed for Site 11 RI										
11MW01	14 - 24	24.2	A		X	X	X	VOCs	VOCs	VOCs
11MW02	8 – 16	14.5	A/D		X	X	X	VOCs	VOCs	VOCs
11MW03	35 – 55	16	D		X	X	X	VOCs		VOCs
11MW04	19 – 34	15	D		X	X	X	VOCs		VOCs
11MW05	24 - 39	15	D		X	X	X	VOCs	VOCs	VOCs
11MW06	23 - 38	21	D		X	X	X	VOCs	VOCs	VOCs
11MW07	15 – 30	28.6	A/D		X	X	X	VOCs	VOCs	VOCs
11MW08	13 – 28	27.7	A		X	X	X	VOCs	VOCs	VOCs
11MW09	27 – 42	10	D			X	X		VOCs	VOCs
11MW10	31 – 46	7	D			X	X		VOCs	VOCs
11MW11	30 – 45	11	D			X	X		VOCs	VOCs
11MW12	9 – 19	18.4	A/D			X	X		VOCs, Diox[a]	VOCs
11MW13	16 – 31	31.2	A			X	X		VOCs	VOCs
11MW14	8.2 - 18.2	17[b]	A/D				X[c]			VOCs
11MW15	22.5 – 37.5	10.5	D				X[c]			VOCs
11MW16	20 - 35	35	A				X			VOCs
Existing Building 1011 Area Wells										
1011MW01	45 - 60	20	D	X	X	X	X			
1011MW02	45 - 60	17	D	X	X	X	X			
1011MW03	45 - 60	18	D	X	X	X	X			
1011MW04	45 - 60	30	D	X	X	X	X			VOCs
1011MW07	25 - 40	18	D	X	X	X	X	VOCs, Diox		VOCs
1011MW08	20 - 35	18	D	X	X	X	X			
Existing Building 710 (Petroleum LNAPL Area) Wells										
MW710-1	30 - 45	30	D	[d]	X	X	X			
710MW01	32 - 42	26	D	[d]	X	X	X			
710MW02	26 - 36	28	D	X	X	X	X			
710MW03	26 - 36	23	D	X	X	X	X			VOCs
710MW04	30 - 40	28	D	X	X	X	X			
Existing Sites 2 and 3 Wells										
2WPMW01	17.5 - 27.5	27	A	X	X	X	X			
MW-3	10 - 40	NR	A/D	X	X	X	X			
MW-4	8 - 33	NR	A/D		X	X	X			
LFW-6	42.9 - 53	NR	D		X[e]	X[e]	X[e]			
LFW-7	10 - 25	NR	D		X[e]	X[e]	X[e]			
LFW-8	8.2 - 18	15.2	A/D		X[e]	X[e]	X[e]			VOCs
LFW-13	13 - 23	NR	A/D		X[e]	X[e]	X[e]			
LFW-14	13.4 - 23	NR	A/D		X[e]	X[e]	X[e]			
LFW-19	14 - 24	NR	A/D	X	X	X	X			
LFW-20	8.6 - 23.6	24	A	X	X	X	X			

[a]Well was sampled separately on August 5, 2009 for 1,4-dioxane

[b]Well installed using direct-push method north of East Toll Gate Creek; no lithology available

[c]Water level had not stabilized; water levels periodically measured through 9/3/10 for 11MW15 & 1011MW07 and 9/10/10 for 11MW14 & LFW08.

[d]Water-level measurements were not taken as proposed in Final Site 11 RI QPP (these wells contain sorbent socks, three adjacent wells are monitored)

[e]Water-level measurements were not proposed for these wells in the Final Site 11 RI QPP (added to provide additional control points)

A - Alluvial aquifer
D - Denver Formation aquifer
Diox - 1,4-dioxane
ft bgs - feet below ground surface
LNAPL - light non-aqueous phase liquid
NR - not reported in previous documents
QPP - Quality Program Plan
RI - Remedial Investigation
VOCs - volatile organic compounds

Table 2-4
Summary of Direct-Push Groundwater Sampling
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Drilled (Pushed) Date	Sample Date	Total Depth or Screen Interval (ft bgs)	Last Measured Water Level (ft bgs)	Length of Water Column (feet)	Observations Recorded[a]
On Base						
11DP01	6/24/2009	6/24/2009	19.05	9.26	9.79	No water at 18.5 ft bgs; deepened to about 20 ft bgs
11DP02	6/24/2009	6/24/2009	20.00	14.70	5.30	No water at 15 ft bgs; deepened to about 20 ft bgs
11DP03	6/24/2009	6/24/2009	19.43	9.26	10.17	No water at 15 ft bgs; deepened to about 20 ft bgs
11DP04	6/24/2009	6/24/2009	26.90	15.30	11.60	Only 0.37 foot water at 25.57 ft bgs, so deepened hole
11DP05	6/24/2009	6/24/2009	25.80	15.50	10.30	
11DP06	6/24/2009	6/24/2009	26.50	15.60	10.90	No water at 25 ft bgs, so deepened hole
11DP07	6/24/2009	6/24/2009	20.62	17.81	2.81	
11DP08	6/24/2009	6/24/2009	27.15	17.60	9.55	
11DP09	6/25/2009	6/25/2009	22.60	19.83	2.77	
11DP10	6/25/2009	6/25/2009	28.12	16.50	11.62	Bedrock about 25.5-26 ft bgs; top 0.6-0.7 foot weathered
11DP11	6/25/2009	6/26/2009	24.23	21.13	3.10	Bedrock about 22 ft bgs; left open overnight; may be part rain
11DP12	6/25/2009	6/25/2009	25.53	15.30	10.23	
11DP13	6/25/2009	6/25/2009	28.35	15.90	12.45	
11DP14	6/25/2009	6/25/2009	20.25	16.76	3.49	
11DP15	6/25/2009	6/26/2009	22.95	18.83	4.12	Bedrock about 22 ft bgs; left open overnight; may be part rain
11DP16	6/25/2009	6/25/2009	27.30	15.35	11.95	
11DP17	6/25/2009	6/25/2009	18.30	13.60	4.70	
11DP18	6/25/2009	6/25/2009	25.25	14.80	10.45	
11DP19	6/25/2009	6/25/2009	20.20	17.25	2.95	
11DP20	6/26/2009	6/26/2009	28.25	16.10	12.15	Hole caved in while pushing
11DP21	6/26/2009	6/26/2009	21.95	11.43	10.52	
11DP22	6/26/2009	6/26/2009	23.00	13.52	9.48	Hole caved in while pushing
11DP23	6/26/2009	NA	21.30	21.25	0.05	Not enough water to sample; data not needed
11DP24	6/26/2009	6/26/2009	25.55	15.27	10.28	
11DP25	6/26/2009	6/26/2009	22.68	2.87	19.81	
11DP26	6/26/2009	6/26/2009	24.20	14.70	9.50	
11DP27	6/26/2009	6/26/2009	22.10	19.30	2.80	No water initially; water after 5 hours and rain
11DP28	6/26/2009	6/26/2009	19.60	0.10	19.50	
11DP29	6/26/2009	NA	13.60	Dry	0	No water; data not needed
11DP30	6/26/2009	6/26/2009	18.65	8.53	10.12	
11DP31	6/26/2009	6/26/2009	20.19	9.24	10.95	
11DP32	6/26/2009	6/26/2009	20.20	14.83	5.37	
Off Base, South of East Toll Gate Creek						
11DP33	2/17/2010	2/17/2010	10 - 14	9.5	4.5	Hole had caved in when measured, to 12.3 ft bgs
11DP34	2/17/2010	2/17/2010	9 - 13	9.9	3.1	
11DP35	2/17/2010	2/17/2010	9 - 13	NM	NM	
11DP36	2/17/2010	2/17/2010	15 - 19	NM	NM	Initial hole to 13 ft bgs had no water after 3/4 hour, so deepened
11DP37	2/17/2010	2/17/2010	9 - 13	NM	NM	
11DP38	2/17/2010	2/17/2010	15 - 19	NM	NM	Initial hole to 13 ft bgs had no water after 1/4 hour, so deepened
11DP39	2/17/2010	2/17/2010	15 - 19	NM	NM	Initial hole to 13 ft bgs had no water, so deepened
11DP40	2/17/2010	2/17/2010	15 - 19	11.8[b]	7.2[b]	No water initially; sampled with tubing after 1 hour
11DP41	2/17/2010	2/17/2010	15 - 19	NM	NM	Slow water producer
11DP42	2/17/2010	2/18/2010	9 - 13	9.8	3.2	Initial hole; no water after 0.5 hour; sampled with tubing next day
	2/17/2010	2/18/2010	15 - 19	9.7	9.3	No water after about 1 hour; sampled with tubing next day
11DP43	2/18/2010	2/18/2010	15 - 19	9.45	9.6	Water level after sampling
11DP44	2/18/2010	2/18/2010	15 - 19	10.0	9.0	Slow water producer; water level 0.5 hour after sampling
11DP45	2/18/2010	2/18/2010	15 - 19	NM	NM	Slow water producer
11DP46	2/18/2010	2/18/2010	15 - 19	NM	NM	Stiff from 12 feet down; slow water producer
11DP47	2/18/2010	2/18/2010	15 - 19	NM	NM	Rapid water producer
11DP48	2/18/2010	2/18/2010	15 - 19	NM	NM	Moderate water producer
11DP49	2/18/2010	2/18/2010	15 - 19	NM	NM	Moderate water producer
11DP50	2/18/2010	2/18/2010	15 - 19	NM	NM	Moderate water producer
11DP51	2/18/2010	NA	NA	Dry	0.0	No water after 2 hours; data not needed
11DP52	2/18/2010	2/18/2010	15 - 19	10.2	8.8	Slow water producer; water level after sampling
11DP53	2/18/2010	2/18/2010	15 - 19	10.4	8.6	Rapid water producer, but turbid; water level after sampling
11DP54	2/18/2010	2/18/2010	15 - 19	NM	NM	Rapid water producer, and clear; water level after sampling
11DP55	2/18/2010	2/18/2010	15 - 19	NM	NM	Moderate water producer

Table 2-4
Summary of Direct-Push Groundwater Sampling
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Drilled (Pushed) Date	Sample Date	Total Depth or Screen Interval (ft bgs)	Last Measured Water Level (ft bgs)	Length of Water Column (feet)	Observations Recorded[a]
Off Base, North of East Toll Gate Creek						
11DP56	5/26/2010	5/26/2010	14 - 18	9.0	9.0	Initial hole to 13 ft bgs; water also slow to enter deeper hole
11DP57	5/26/2010	5/26/2010	15 - 19	8.0	11.0	Turbid water
11DP58	5/26/2010	5/26/2010	10 - 14	9.5	4.5	Clear water
11DP59	5/26/2010	5/27/2010	10 - 14	8.7	5.3	No water initially; sampled with tubing next day
11DP60	5/26/2010	5/26/2010	10 - 14	NM	NM	No water initially; sampled with tubing after 2 hours
11DP61	5/26/2010	5/26/2010	10 - 14	10.2	3.8	Rapid water producer
11DP62	5/26/2010	5/26/2010	10 - 14	10.4	3.6	Hole caved in
11DP63	5/26/2010	5/26/2010	10 - 14	NM	NM	
11DP64	5/26/2010	5/26/2010	10 - 14	NM	NM	Clear water
11DP65	5/26/2010	5/26/2010	10 - 14	NM	NM	
11DP66	5/26/2010	5/26/2010	10 - 14	NM	NM	
11DP67	5/26/2010	5/26/2010	10 - 14	NM	NM	
11DP68	5/26/2010	5/26/2010	10 - 14	NM	NM	
11DP69	5/26/2010	5/26/2010	10 - 14	NM	NM	Slow water producer
11DP70	5/27/2010	5/27/2010	10 - 14	NM	NM	Turbid water; sand recovered with water
11DP71	5/27/2010	5/27/2010	10 - 14	NM	NM	
11DP72	5/27/2010	5/27/2010	10 - 14	NM	NM	Silt and sand recovered with water
11DP73	5/27/2010	5/27/2010	10 - 14	NM	NM	
11DP74	5/27/2010	5/27/2010	10 - 14	NM	NM	
11DP75	5/27/2010	5/27/2010	10 - 14	NM	NM	No water initially; sampled with tubing after 1.5 hours
11DP76	5/27/2010	NA	10 - 14	Dry	0.0	No water initially; left tubing hole overnight and still dry
11DP77	5/27/2010	5/27/2010	10 - 14	NM	NM	Slow water producer
11DP78	5/27/2010	NA	10 - 14	Dry	0.0	No water initially; left tubing hole overnight and still dry
11DP79	5/27/2010	5/27/2010	10 - 14	NM	NM	
11DP80	5/27/2010	5/27/2010	10 - 14	NM	NM	Silty; slow water producer
11DP81	5/27/2010	5/27/2010	10 - 14	NM	NM	Slow water producer
11DP82	5/27/2010	5/27/2010	10 - 14	NM	NM	

[a]If no observations were noted, groundwater typically entered the hole sufficiently to sample without delay
[b]Water level had not stabilized, based on other water levels

ft bgs - feet below ground surface
NA - not applicable
NM - not measured

Table 3-1
RI Ground Water-Level Measurements
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Stick-up (feet)	Measured Total Depth from MP (6/23/10) (feet)	3/5/2009			4/8/2009			7/10/2009			6/23/2010		
					Depth to Water from MP (feet)	Depth to Water from Ground Surface (feet)	Water Elevation (ft amsl)	Depth to Water from MP (feet)	Depth to Water from Ground Surface (feet)	Water Elevation (ft amsl)	Depth to Water from MP (feet)	Depth to Water from Ground Surface (feet)	Water Elevation (ft amsl)	Depth to Water from MP (feet)	Depth to Water from Ground Surface (feet)	Water Elevation (ft amsl)
New RI Wells																
11MW01	5513.37	5516.67	3.30	27.49	NM	NM	NM	12.59	9.29	5504.08	11.25	7.95	5505.42	11.64	8.34	5505.03
11MW02	5515.68	5515.18	-0.50	15.59	NM	NM	NM	10.69	11.19	5504.49	9.36	9.86	5505.82	9.69	10.19	5505.49
11MW03	5526.78	5525.97	-0.81	53.86	NM	NM	NM	22.26	23.07	5503.71	21.00	21.81	5504.97	19.81	20.62	5506.16
11MW04	5538.90	5541.76	2.86	36.50	NM	NM	NM	31.05[a]	28.19[a]	5510.71[a]	22.42	19.56	5519.34	20.85	17.99	5520.91
11MW05	5534.61	5537.51	2.90	41.38	NM	NM	NM	29.28	26.38	5508.23	27.41	24.51	5510.10	27.02	24.12	5510.49
11MW06	5527.67	5530.55	2.88	40.43	NM	NM	NM	24.39	21.51	5506.16	22.54	19.66	5508.01	22.68	19.80	5507.87
11MW07	5522.27	5525.49	3.22	33.26	NM	NM	NM	18.64	15.42	5506.85	16.72	13.50	5508.77	16.66	13.44	5508.83
11MW08	5517.01	5520.15	3.14	30.50	NM	NM	NM	14.59	11.45	5505.56	12.85	9.71	5507.30	13.17	10.03	5506.98
11MW09	5538.80	5541.36	2.56	44.49	NM	NM	NM	NM	NM	NM	29.83	27.27	5511.53	29.49	26.93	5511.87
11MW10	5536.92	5536.43	-0.49	45.59	NM	NM	NM	NM	NM	NM	26.34	26.83	5510.09	25.91	26.40	5510.52
11MW11	5538.40	5541.23	2.83	46.68	NM	NM	NM	NM	NM	NM	29.44	26.61	5511.79	29.15	26.32	5512.08
11MW12	5514.54	5513.95	-0.59	18.94	NM	NM	NM	NM	NM	NM	8.26	8.85	5505.69	8.64	9.23	5505.31
11MW13	5521.10	5524.09	2.99	33.86	NM	NM	NM	NM	NM	NM	17.12	14.13	5506.97	17.44	14.45	5506.65
11MW14[b]	5510.05	5512.03	1.98	20.35	NM	NM	NM	NM	NM	NM	NM	NM	NM	*17.72*[b]	*15.74*[b]	*5494.31*[b]
11MW15[c]	5536.99	5536.56	-0.43	37.10	NM	NM	NM	NM	NM	NM	NM	NM	NM	*36.04*[c]	*36.48*[c]	*5500.52*[c]
11MW16	5525.84	5528.56	2.72	37.85	NM	NM	NM	NM	NM	NM	NM	NM	NM	20.52	17.80	5508.04
Previously Existing Wells - Site 11																
MW710-1	5536.45	5538.09	1.64	43.90	NM	NM	NM	29.24	27.60	5508.85	27.76	26.12	5510.33	27.06	25.42	5511.03
710MW01	5537.25	5540.07	2.82	43.38	NM	NM	NM	30.62	27.80	5509.45	29.14	26.32	5510.93	28.94	26.12	5511.13
710MW02	5534.38	5537.24	2.86	38.74	28.20	25.34	5509.04	28.36	25.50	5508.88	26.79	23.93	5510.45	26.05	23.19	5511.19
710MW03	5534.07	5536.78	2.71	38.27	27.95	25.24	5508.83	28.09	25.38	5508.69	26.40	23.69	5510.38	25.77	23.06	5511.01
710MW04	5533.87	5536.62	2.75	42.22	27.80	25.05	5508.82	27.95	25.20	5508.67	26.27	23.52	5510.35	25.57	22.82	5511.05
1011MW01	5550.32	5552.81	2.49	61.80	43.27	40.78	5509.54	43.60	41.11	5509.21	42.23	39.74	5510.58	41.24	38.75	5511.57
1011MW02	5538.14	5540.83	2.69	58.05	25.84	23.15	5514.99	25.49	22.80	5515.34	23.14	20.45	5517.69	22.76	20.07	5518.07
1011MW03	5532.17	5534.94	2.77	62.67	30.38	27.61	5504.56	30.34	27.57	5504.60	30.09	27.32	5504.85	29.13	26.36	5505.81
1011MW04	5534.16	5536.52	2.36	60.75	30.39	28.03	5506.13	30.25	27.89	5506.27	29.55	27.19	5506.97	27.56	25.20	5508.96
1011MW05[d]	5530.79	5533.81	3.02	42.62[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	*5511.44*[d]
1011MW06[d]	5526.18	5528.95	2.77	32.60[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]	NM[d]
1011MW07	5538.04	5540.95	2.91	42.75	27.43	24.52	5513.52	27.86	24.95	5513.09	27.73	24.82	5513.22	26.47	23.56	5514.48
1011MW08	5538.39	5541.40	3.01	38.17	25.04	22.03	5516.36	25.24	22.23	5516.16	23.46	20.45	5517.94	22.60	19.59	5518.80
Previously Existing Wells - Sites 2 and 3																
2WPMW01	5521.26	5524.12	2.86	29.48	17.08	14.22	5507.04	16.80	13.94	5507.32	15.05	12.19	5509.07	14.96	12.10	5509.16
MW-3	5521.54	5524.22	2.68	18.58[e]	17.17	14.49	5507.05	16.94	14.26	5507.28	15.15	12.47	5509.07	14.99	12.31	5509.23
MW-4	5518.98	5521.34	2.36	35.57	NM	NM	NM	14.62	12.26	5506.72	12.90	10.54	5508.44	13.09	10.73	5508.25
LFW-6	5544.92	5547.49	2.57	54.37	NM	NM	NM	31.63	29.06	5515.86	27.97	25.40	5519.52	27.73	25.16	5519.76
LFW-7	5524.59	5526.01	1.42	27.62	NM	NM	NM	14.21	12.79	5511.80	10.55	9.13	5515.46	10.94	9.52	5515.07
LFW-8	5508.61	5510.05	1.44	19.40	NM	NM	NM	14.41	12.97	5495.64	11.11	9.67	5498.94	11.55	10.11	5498.50
LFW-13	5520.63	5522.22	1.59	25.39	NM	NM	NM	10.09	8.50	5512.13	6.71	5.12	5515.51	7.61	6.02	5514.61
LFW-14	5526.65	5528.67	2.02	24.93	NM	NM	NM	12.72	10.70	5515.95	9.25	7.23	5519.42	9.98	7.96	5518.69
LFW-19	5519.49	5521.48	1.99	23.44	15.05	13.06	5506.43	14.69	12.70	5506.79	13.01	11.02	5508.47	13.22	11.23	5508.26
LFW-20	5515.75	5518.52	2.77	26.98	10.58	7.81	5507.94	9.83	7.06	5508.69	7.58	4.81	5510.94	8.13	5.36	5510.39

[a]Water-level did not appear to have stabilized.

[b]Water-level did not appear to have stabilized; the potentiometric surface for 11MW14 was interpreted based on the 9/10/10 water level in this well (5498.86), increased to reflect the fall in the water level in well LFW-8 between 6/23/10 and 9/10/10 (1.79 feet), and an additional estimated 0.58 feet rise to stabilize. The estimated additional rise to stabilize was based on the diminishing differences between the weekly measurement changes in these two wells. The estimated 6/23/10 elevation is 5501.23.

[c]Water-level did not appear to have stabilized. The potentiometric surface for 11MW15 was interpreted based on the 7/21/2010 water level in this well (5512.11), decreased to reflect the rise in the water level in well 1011MW07 between 6/23/10 and 7/21/10 (0.41 feet). The estimated 6/23/10 elevation is 5511.70.

[d]Wells 1011MW05 and 1011MW06 were abandoned before initial RI field work; the 6/23/10 potentiometric surface for 1011MW05 was interpreted based on 2006 water levels, adjusted to reflect the change in well 1011MW04 between these two time periods. For well 1011MW05, the 6/30/06 water elevation was 5505.28; assuming an increase similar to well 1011MW04 (6.16 feet), the estimated 6/23/10 elevation is 5511.44.

[e]Well appears to have an obstruction; previous listed depth was 42.68 feet.

ft amsl - feet above mean sea level

MP - measuring point

NM - not measured

Table 3-2
Detections of VOCs and Results for 1,4-Dioxane
in Wells Sampled Under the Site 11 RI
Buckley Air Force Base, Colorado

Sampling Location/ Well ID	Sample Date	Screened Interval (ft bgs)	Aquifer	PCE	TCE	cis-1,2-DCE	1,2-DCA	Carbon Tetra-chloride	Chloro-form	Methylene Chloride	BDCM	1,2-Dichloro-propane	Acetone	Benzene	Toluene	p- (or 4-) Isopropyl toluene	1,2,4-TMB	m,p- (or total) Xylenes	o- (or total) Xylenes	Naphtha-lene	1,4-Dioxane
Regulatory Standard (ug/L):				5[M]	5[M]	70[M]	0.38 - 5[M]	0.27 - 5[M]	3.5	4.7 - 5[M]	0.56	0.52 - 5[M]	6,300[a]	5[M]	560 -1000[M]	None	350[a]	1,400-10,000[M]	1,400-10,000[M]	140	6.1
PCE Plume (Well 1011MW06 Area)																					
1011MW06	6/1/06	20 - 30	A/D	**= 40.8**	= 1.96	= 0.636 F	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW01	3/23/09	14 - 24	A	= 0.633 F	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	7/7/09			= 0.336 F	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/24/10			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW02	3/24/09	8 - 16	A/D	= 1.99	= 0.291 F	< 0.250	< 0.250	< 0.250	= 0.156 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	7/7/09			= 4.69	= 0.646 F	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/24/10			**= 9.68**	= 1.07	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05	3/23/09	24 - 39	D	**= 71.5**	= 1.64	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	= 11.4	< 0.125	< 0.250	= 1.58 J	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05D				**= 67.4**	= 1.63	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	= 6.66 F	< 0.125	< 0.250	= 1.09 J	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05	7/7/09			**= 60.2**	= 1.03	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05D				**= 157**	= 2.18	< 0.250	< 0.250	< 0.250	= 0.132 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05	6/25/10			**= 34.1 J**	= 0.876 F	< 0.250	< 0.250	< 0.250	= 0.405	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW05D				**= 43.2 J**	= 0.940 F	< 0.250	< 0.250	< 0.250	= 0.371	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW06	3/23/09	23 - 38	D	< 0.250	= 2.29	= 0.371 F	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	= 3.51 F	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	7/7/09			= 0.304 F	= 3.31	= 0.361 F	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/24/10			= 0.985 F	= 4.16	= 0.438 F	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW07	3/23/09	15 - 30	A/D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.762	< 0.250	= 0.448 F	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	7/8/09			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.862	< 0.250	= 0.515	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/24/10			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 1.15	< 0.250	**= 0.721**	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW08	3/23/09	13 - 28	A	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	7/7/09			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.128 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/24/10			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.303	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW09	7/7/09	27 - 42	D	= 1.08	< 0.250	< 0.250	< 0.250	< 0.250	= 0.914	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/25/10			= 2.11	< 0.250	< 0.250	< 0.250	< 0.250	= 1.08	< 0.250	= 0.436 F	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW10	7/8/09	31 - 46	D	**= 11.6**	= 0.470 F	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/25/10			**= 30.8**	= 0.940 F	< 0.250	< 0.250	< 0.250	= 0.201 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW11	7/8/09	30 - 45	D	**= 14.0**	< 0.250	< 0.250	< 0.250	**= 0.283 F**	= 0.714	< 0.250	= 0.276 F	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/25/10			**= 9.54**	< 0.250	< 0.250	< 0.250	< 0.250	= 0.663	< 0.250	= 0.294 F	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW12	7/7/09	9 - 19	A/D	**= 22.5**	= 0.334 F	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	8/5/09			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	< 0.500 M
	6/24/10			**= 14.4**	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW13	7/8/09	16 - 31	A	**= 45.7**	= 1.52	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/25/10			**= 35.5**	= 0.968 F	< 0.250	< 0.250	< 0.250	= 0.135 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW14	7/8/10	8.2 - 18.2	A/D	= 0.821 F	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	= 0.541	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW16	6/25/10	20 - 35	A	**= 25.1**	= 0.463 F	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	= 0.376 F	< 0.250	= 0.672 F	= 0.749 F	= 0.305 F	= 0.399 F	NA
11MW16D				**= 25.2**	= 0.388 F	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	= 0.375 F	< 0.250	= 0.711 F	= 0.746 F	= 0.309 F	= 0.438 F	NA
710MW03	5/23/06	26 - 36	D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.144 F	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/23/10			= 0.536 F	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
LFW-8	12/88	8.2 - 18	A/D	NA	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 100	< 5.0	< 5.0	NA	NA	< 5.0 (total)	< 5.0 (total)	< 10	NA
	8/22/91			< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 10	< 5.0	< 5.0	NA	NA	< 5.0 (total)	< 5.0 (total)	< 9.0	NA
	7/18/06			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	Na
	6/25/10			= 0.279 F	= 1.08	= 0.486	< 0.250	< 0.250	< 0.125	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
North Plume (Well 1011MW07 Area)																					
1011MW04	5/26/06	45 - 60	D	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.200 L	= 8.50 F	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L	NA
1011MW04D	5/26/06			< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.125 L	< 0.250 L	< 0.250 L	< 0.200 L	= 6.49 F	< 0.125 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.250 L	< 0.200 L	NA
1011MW04	6/24/10			< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.434	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
1011MW07	6/1/06	25 - 40	D	< 0.250	**= 7.81**	< 0.250	**= 1.50**	**= 7.10**	**= 25.8**	= 0.602 F	< 0.250	< 0.200	= 4.05 F	= 0.479	= 0.796 F	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	3/24/09			< 0.250	**= 61.3**	< 0.250	**= 4.86**	**= 90.7**	**= 78.1**	= 0.463 F	< 0.250	= 0.232 F	< 2.50	= 3.97	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	< 0.500
	6/23/10			< 0.250	**= 65.8**	< 0.250	**= 6.02**	**= 140**	**= 93.8**	= 1.15	< 0.250	= 0.264 F	< 2.50	= 1.13	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW03	3/24/09	35 - 55	D	< 0.250	= 0.304 F	< 0.250	< 0.250	< 0.250	= 1.37	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/23/10			< 0.250	= 0.257 F	< 0.250	< 0.250	< 0.250	= 0.436	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW04	3/24/09	19 - 34	D	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 1.20	< 0.250	< 0.250	< 0.200	= 21.8	< 0.125	< 0.250	= 0.268 F	< 0.250	< 0.250	< 0.250	< 0.200	NA
	6/23/10			< 0.250	= 0.582 F	< 0.250	< 0.250	**= 0.626 F**	**= 4.46**	< 0.250	< 0.250	< 0.200	< 2.50	< 0.125	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.200	NA
11MW15	7/1/10	22.5 - 37.5	D	< 0.250	= 2.39	< 0.250	**= 1.09**	**= 3.67**	**= 17.6**	= 0.446 F	< 0.250	< 0.200	= 2.88 F	= 0.699	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	= 0.240 F	NA

Notes:

Regulatory standards are the Colorado Basic Standards for Groundwater (CBSG), Regulation 41 (11/30/09). CBSGs that are the drinking water MCL are identified with an "M".
The first number in a range is a health-based value, and may not be applicable for releases before 9/14/04.
Bold indicates analytical result exceeds regulatory standard and which standard(s) is exceeded.

Footnotes:

[a]There is no CBSG; the standard listed is a water standard from Table 1 - Colorado Soil Evaluation Values (CSEVs) - December 2007 (CDPHE)

Qualifiers:

= - detected
< - not detected at the MDL shown
F - analyte positively identified, but value is below the RL
J - analyte positively identified; the quantitation is an estimation
L - sample analyzed within 1 to 1.5 times the holding time
M - a matrix effect was present

Abbreviations:

A - Alluvial aquifer
BDCM - bromodichloromethane
CDPHE - Colorado Department of Public Health and Environment
D - Denver Formation aquifer
DCA - dichloroethane
DCE - dichloroethene
ft bgs - feet below ground surface
MCL - maximum contaminant level
MDL - method detection limit
NA - not analyzed
PCE - tetrachloroethene
TCE - trichloroethene
TMB - trimethylbenzene
RL - reporting limit
ug/L - micrograms per liter

Table 3-3
Summary of June 2009 On-Base Groundwater Grab Sampling and Analysis
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Sample Date	Total Depth (ft bgs)	Water Level (ft bgs)	PCE Concentration	TCE Concentration	C12DCE Concentration
Regulatory Standard (ug/L)[a]:				**5**	**5**	**70**
11DP01	6/24/2009	19.05	9.26	<0.382	<0.268	<0.451
11DP02	6/24/2009	20.00	14.70	<0.382	<0.268	<0.451
11DP03	6/24/2009	19.43	9.26	<0.382	<0.268	<0.451
11DP04	6/24/2009	26.90	15.30	<0.382	<0.268	<0.451
11DP05	6/24/2009	25.80	15.50	<0.382	<0.268	<0.451
11DP06	6/24/2009	26.50	15.60	<0.382	<0.268	<0.451
11DP07	6/24/2009	20.62	17.81	<0.382	<0.268	<0.451
11DP08	6/24/2009	27.15	17.60	<0.382	<0.268	<0.451
11DP09	6/25/2009	22.60	19.83	**36 (40 in Dup)**	<0.268	<0.451
11DP10	6/25/2009	28.12	16.50	**20**	<0.268	<0.451
11DP11	6/26/2009	24.23	21.13	<0.382[b]	<0.268	<0.451
11DP12	6/25/2009	25.53	15.30	<0.382	<0.268	<0.451
11DP13	6/25/2009	28.35	15.90	<0.382	<0.268	<0.451
11DP14	6/25/2009	20.25	16.76	**12**	<0.268	<0.451
11DP15	6/26/2009	22.95	18.83	<0.382[b]	<0.268	<0.451
11DP16	6/25/2009	27.30	15.35	<0.382	<0.268	<0.451
11DP17	6/25/2009	18.30	13.60	1.2	<0.268	<0.451
11DP18	6/25/2009	25.25	14.80	**7.9**	<0.268	<0.451
11DP19	6/25/2009	20.20	17.25	**6.4**	<0.268	<0.451
11DP20	6/26/2009	28.25	16.10	**24**	1.6	<0.451
11DP21	6/26/2009	21.95	11.43	<0.382	<0.268	<0.451
11DP22	6/26/2009	23.00	13.52	**32**	<0.268	<0.451
11DP23	NA	21.30	21.25	NA	<0.268	<0.451
11DP24	6/26/2009	25.55	15.27	3.5	<0.268	<0.451
11DP25	6/26/2009	22.68	2.87	<0.382	<0.268	<0.451
11DP26	6/26/2009	24.20	14.70	**26**	2.0	<0.451
11DP27	6/26/2009	22.10	19.30	2.9[b]	<0.268	<0.451
11DP28	6/26/2009	19.60	0.10	**18**	<0.268	<0.451
11DP29	NA	13.60	Dry	NA	<0.268	<0.451
11DP30	6/26/2009	18.65	8.53	4.0	<0.268	<0.451
11DP31	6/26/2009	20.19	9.24	<0.382	<0.268	<0.451
11DP32	6/26/2009	20.20	14.83	<0.382	<0.268	<0.451
11MW05[c]	6/24/2009	NM	NM	**200[c]**	3.3	<0.451
11MW09[c]	6/29/2009	43	NM	<0.382[c]	<0.268	<0.451

C12DCE - cis-1,2-dichloroethene
CBSG - Colorado Basic Standard for Groundwater
Dup - duplicate sample (for quality assessment)
ft bgs - feet below ground surface
MDL - method detection limit
NA - not applicable
NM - not measured
PCE - tetrachloroethene
TCE - trichloroethene
ug/L - micrograms per liter
VOC - volatile organic compound
< - not detected above the listed MDL

Bolded concentrations exceed CBSGs.
No other VOCs analyzed (trans-1,2-dichloroethene, chloroform, vinyl chloride) were detected above their MDLs.

[a]Groundwater standards are the CBSGs, Regulation 41 (11/30/09).
[b]Result may be diluted; initially dry, then rainstorm occurred before sample could be collected.
[c]Grab sample collected for screening purposes.

Table 3-4
Summary of February 2010 Off-Base Groundwater, Surface Water, and Sediment Sampling and Analysis
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Sample Date	Screen Interval (ft bgs)	Water Level (ft bgs)	PCE Concentration	TCE Concentration	C12DCE Concentration
Groundwater - Regulatory Standard (ug/L)[a]:				**5**	**5**	**70**
11DP33	2/17/2010	10 - 14	9.5	2.9	2.5	<0.451
11DP34	2/17/2010	9 - 13	9.9	2.0	0.85 F	<0.451
11DP35	2/17/2010	9 - 13	NM	0.76 F	<0.268	<0.451
11DP36	2/17/2010	15 - 19	NM	3.1 (2.8 in Dup)	3.3 (3.4 in Dup)	<0.451
11DP37	2/17/2010	9 - 13	NM	0.52 F	<0.268	<0.451
11DP38	2/17/2010	15 - 19	NM	<0.382	<0.268	<0.451
11DP39	2/17/2010	15 - 19	NM	1.2	<0.268	<0.451
11DP40	2/17/2010	15 - 19	11.8	2.1	0.93 F	<0.451
11DP41	2/17/2010	15 - 19	NM	1.1	1.4	<0.451
11DP42	2/18/2010	9 - 13	9.8	0.81 F	<0.268	<0.451
	2/18/2010	15 - 19	9.7	<0.382	<0.268	<0.451
11DP43	2/18/2010	15 - 19	9.45	2.9	4.4	<0.451
11DP44	2/18/2010	15 - 19	10.0	<0.382	1.2	<0.451
11DP45	2/18/2010	15 - 19	NM	<0.382	<0.268	<0.451
11DP46	2/18/2010	15 - 19	NM	<0.382	<0.268	<0.451
11DP47	2/18/2010	15 - 19	NM	1.0	0.75 F	<0.451
11DP48	2/18/2010	15 - 19	NM	1.2	0.75 F	<0.451
11DP49	2/18/2010	15 - 19	NM	1.3	0.80 F	<0.451
11DP50	2/18/2010	15 - 19	NM	0.63 F	0.78 F	<0.451
11DP51	NA	NA	Dry	NA	NA	NA
11DP52	2/18/2010	15 - 19	10.2	<0.382	<0.268	<0.451
11DP53	2/18/2010	15 - 19	10.4	<0.382	<0.268	<0.451
11DP54	2/18/2010	15 - 19	NM	2.2	2.0	<0.451
11DP55	2/18/2010	15 - 19	NM	<0.382	<0.268	<0.451
Surface Water - Regulatory Standard (ug/L)[b,c]				**3.3**	**30**	**None**
11CK01	2/18/2010	NA	NA	<0.382 / 0.304 F	<0.268 / 0.380 F	<0.451 / <0.250
11CK02	2/18/2010	NA	NA	<0.382 / 0.429 F	<0.268 / 0.299 F	<0.451 / <0.250
11CK03	2/18/2010	NA	NA	<0.382 / 0.470 F	<0.268 / 0.280 F	<0.451 / <0.250
Sediment - Screening Level (ug/kg)[c,d]				**450 - 550**	**39 - 2,800**	**42,000 - 780,000**
11CK01	2/18/2010	NA	NA	<1.512 / <1.02	<1.096 / <1.02	<1.022 / <1.02
11CK02	2/18/2010	NA	NA	<1.512 / <0.713	2.1 F / 1.15 F	<1.022 / <0.713
11CK03	2/18/2010	NA	NA	<1.512 / <0.869	10 / 3.63 F	13 / 2.91 F

C12DCE - cis-1,2-dichloroethene
Dup - duplicate sample (for quality assessment)
F - detected between the MDL and RL
ft bgs - feet below ground surface
MDL - method detection limit
NA - not applicable
NM - not measured
PCE - tetrachloroethene
RL - reporting limit
TCE - trichloroethene
ug/kg- micrograms per kilogram
ug/L - micrograms per liter
VOC - volatile organic compound
< - not detected above the listed MDL

No other VOCs analyzed (trans-1,2-dichloroethene, chloroform, vinyl chloride by the on-site lab; full suite by the fixed-based lab) were detected above their MDLs.

[a]Groundwater standards are the Colorado Basic Standards for Groundwater, Regulation 41 (11/30/09).
[b]Surface water standards are the Colorado Basic Standards and Methodologies for Surface Water (Regulation 31) (Fish Ingestion) (3/30/09).
[c]The first concentration value is from the on-site lab; the second concentration value is from the fixed-base lab.
[d]Sediment screening values are residential Colorado Soil Evaluation Values (12/07) and EPA Regional Screening Levels (5/10).

DP and Creek Feb 2010 data

Table 3-5
Summary of May 2010 Off-Base Groundwater Grab Sampling and Analysis
Site 11 RI
Buckley Air Force Base, Colorado

Site ID	Sample Date	Screen Interval (ft bgs)	Water Level (ft bgs)	PCE Concentration	TCE Concentration	C12DCE Concentration
Regulatory Standard (ug/L)[a]:				**5**	**5**	**70**
11DP56	5/26/2010	14 - 18	9.0	**16**	<0.414	<0.391
11DP57	5/26/2010	15 - 19	8.0	**22**	0.73 F	<0.391
11DP58	5/26/2010	10 - 14	9.5	**11**	0.82 F	<0.391
11DP59	5/27/2010	10 - 14	8.7	**5.2**	<0.414	<0.391
11DP60	5/26/2010	10 - 14	NM	**14**	<0.414	<0.391
11DP61	5/26/2010	10 - 14	10.2	**16**	<0.414	<0.391
11DP62	5/26/2010	10 - 14	10.4	**15**	<0.414	<0.391
11DP63	5/26/2010	10 - 14	NM	<0.431	<0.414	<0.391
11DP64	5/26/2010	10 - 14	NM	**9.5**	<0.414	<0.391
11DP65	5/26/2010	10 - 14	NM	1.9	1.9	5.2
11DP66	5/26/2010	10 - 14	NM	<0.431	<0.414	<0.391
11DP67	5/26/2010	10 - 14	NM	**8.8**	1.8	<0.391
11DP68	5/26/2010	10 - 14	NM	**11**	0.84 F	<0.391
11DP69	5/26/2010	10 - 14	NM	**6.6**	0.63 F	1.0
11DP70	5/27/2010	10 - 14	NM	2.8	<0.414	<0.391
11DP71	5/27/2010	10 - 14	NM	**14**	<0.414	<0.391
11DP72	5/27/2010	10 - 14	NM	**16**	1.0	<0.391
11DP73	5/27/2010	10 - 14	NM	4.1	<0.414	<0.391
11DP74	5/27/2010	10 - 14	NM	**6.6**	1.3	0.62 F
11DP75	5/27/2010	10 - 14	NM	**5.1**	0.67 F	<0.391
11DP76	NA	10 - 14	Dry	NA	NA	NA
11DP77	5/27/2010	10 - 14	NM	<0.431	<0.414	<0.391
11DP78	NA	10 - 14	Dry	NA	NA	NA
11DP79	5/27/2010	10 - 14	NM	**8.1**	<0.414	<0.391
11DP80	5/27/2010	10 - 14	NM	2.6	<0.414	<0.391
11DP81	5/27/2010	10 - 14	NM	2.4	<0.414	<0.391
11DP82	5/27/2010	10 - 14	NM	1.0	<0.414	<0.391

C12DCE - cis-1,2-dichloroethene
CBSG - Colorado Basic Standard for Groundwater
F - detected between the MDL and RL
ft bgs - feet below ground surface
MDL - method detection limit
NA - not applicable
NM - not measured
PCE - tetrachloroethene
RL - reporting limit
TCE - trichloroethene
ug/L - micrograms per liter
VOC - volatile organic compound
< - not detected above the listed MDL

Bolded concentrations exceed CBSGs.
No other VOCs analyzed (trans-1,2-dichloroethene, chloroform, vinyl chloride) were detected above their MDLs.

[a]Groundwater standards are the CBSGs, Regulation 41 (11/30/09).

Table 4-1
Physiochemical Data and PCE and Degradation Products in PCE Plume Monitoring Wells and Surface Water
Site 11 RI
Buckley Air Force Base, Colorado

Well/ Sample No.	Aquifer	Sample Date	PCE ➔ (ug/L)	TCE ➔ (ug/L)	C12DCE (ug/L)	DO (mg/L)	ORP (mV)	pH	Temp (deg. C)	Conduct (mS/cm)
PCE Plume Approximate Centerline - Upgradient to Downgradient										
11MW09	D	7/7/2009	= 1.08	<0.250	<0.250	1.06	-17.5	7.20	21.7	3.517
		6/25/2010	= 2.11	<0.250	<0.250	2.78	214	7.22	15.02	3.575
11MW10	D	7/8/2009	**= 11.6**	= 0.470 F	<0.250	1.50	29.6	6.89	17.77	2.701
		6/25/2010	**= 30.8**	= 0.940 F	<0.250	1.32	342	6.53	15.6	2.791
11MW11	D	7/8/2009	**= 14.0**	<0.250	<0.250	2.97	117.4	7.02	16.24	3.118
		6/25/2010	**= 9.54**	<0.250	<0.250	4.43	232	7.20	14.88	2.916
11MW05	D	3/23/2009	**= 71.5**	= 1.64	<0.250	1.85	98.6	6.97	13.81	2.726
		(Dup)	**= 67.4**	= 1.63	<0.250					
		7/7/2009	**= 60.2**	= 1.03	<0.250	1.84	123.1	6.61	17.25	2.569
		(Dup)	**= 157**	= 2.18	<0.250					
		6/25/2010	**= 34.1 J**	= 0.876 F	<0.250	2.08	269	6.71	14.83	0.792
		(Dup)	**= 43.2 J**	= 0.940 F	<0.250					
1011MW06	A/D	5/25 & 6/1/06	**= 40.8**	= 1.96	= 0.636 F	NM	NM	7.07	14.8	1.814
11MW16	A	6/25/2010	**= 25.1**	= 0.463 F	<0.250	2.00	179	7.10	13.3	2.198
		(Dup)	**= 25.2**	= 0.388 F	<0.250					
11MW13	A	7/8/2009	**= 45.7**	= 1.52	<0.250	1.32	96.4	6.87	15.03	2.432
		6/25/2010	**= 35.5**	= 0.968 F	<0.250	1.71	156	7.18	12.66	2.415
11MW12	A/D	7/6/2009	NA	NA	NA	1.64	96.9	6.82	15.44	2.912
		7/7/2009	**= 22.5**	= 0.334 F	<0.250	1.69	38.4	6.95	14.99	2.920
		8/5/2009	NA	NA	NA	1.86	80.7	6.96	18.16	2.944
		6/24/2010	**= 14.4**	<0.250	<0.250	2.13	201	6.92	13.6	3.136
11MW02	A/D	3/24/2009	= 1.99	= 0.291 F	<0.250	6.75	137.3	7.35	11.49	3.421
		7/7/2009	= 4.69	= 0.646 F	<0.250	2.58	32.8	7.12	14.27	3.358
		6/24/2010	**= 9.68**	= 1.07	<0.250	2.37	115	6.93	13.01	2.975
11MW14	A/D	7/8/2010	= 0.821 F	<0.250	<0.250	8.75	197	7.10	13.8	3.110
LFW-8	A/D	Dec 1988	NM	<5.0	<5.0	NM	NM	NM	NM	NM
		8/22/1991	<5.0	<5.0	<5.0	NM	NM	7.16	13.0	3.080
		7/18/2006	<0.250	<0.250	<0.250	NM	NM	6.50	17.3	2.800
		6/25/2010	= 0.279 F	= 1.08	= 0.486	2.4	163	7.18	10.9	3.822
PCE Plume - Crossgradient (Upgradient to Downgradient)										
710MW03	D	5/23/2006	<0.250	<0.250	<0.250	2.37	82.1	6.81	15.45	2.285
		6/23/2010	= 0.536 F	<0.250	<0.250	2.32	265	6.38	14.02	2.502
11MW06	D	3/23/2009	<0.250	= 2.29	= 0.371 F	1.97	133.4	7.35	13.36	2.088
		7/7/2009	= 0.304 F	= 3.31	= 0.361 F	2.24	62.1	7.10	17.11	2.266
		6/24/2010	= 0.985 F	= 4.16	= 0.438 F	1.56	346.0	6.50	14.85	2.186
11MW07	A/D	3/23/2009	<0.250	<0.250	<0.250	4.37	206.1	7.44	12.36	3.654
		7/8/2009	<0.250	<0.250	<0.250	4.17	121.4	7.00	14.16	3.611
		6/24/2010	<0.250	<0.250	<0.250	4.16	407.0	6.16	13.42	3.689
11MW08	A	3/23/2009	<0.250	<0.250	<0.250	2.77	229.6	7.20	11.9	3.467
		7/7/2009	<0.250	<0.250	<0.250	2.36	72.3	7.01	15.71	3.463
		6/24/2010	<0.250	<0.250	<0.250	2.9	291	6.60	12.64	3.07
11MW01	A	3/23/2009	= 0.633 F	<0.250	<0.250	3.56	180	7.35	11.67	3.972
		7/7/2009	= 0.336 F	<0.250	<0.250	2.04	51.3	6.93	15.36	4.006
		6/24/2010	<0.250	<0.250	<0.250	2.86	208	6.95	12.51	3.998
Surface Water - Upgradient to Downgradient										
11CK03[a]	SW	2/18/2009	= 0.470 F	= 0.280 F	<0.250	10.00	100.6	7.79	8.55[a]	1.590
11CK02[a]	SW	2/18/2009	= 0.429 F	= 0.299 F	<0.250	10.28	101.0	7.88	7.23[a]	3.109
11CK01[a]	SW	2/18/2009	= 0.304 F	= 0.380 F	<0.250	9.49	105.6	7.93	7.58[a]	1.642

Physiochemical parameters measured using field instruments at the end of purging. ➔Degradation pathway

Bolded concentrations exceed CBSGs

[a]Water was containerized and held in cooler with ice until parameters were measured, about 6 hours after collection.

A - alluvial
C12DCE - cis-1,2-dichloroethene
CBSG - Colorado Basic Standards for Groundwater (Regulation 41)
D - Denver Formation
deg. C - degrees Celsius
DO - dissolved oxygen
Dup - duplicate sample
F - analyte positively identified but value is below the reporting limit
J - analyte positively identified; the quantitation is an estimation
mg/L - milligrams per liter
mS/cm - milliSiemens per centimeter
mV - millivolts
NM - not measured
ORP - oxygen reduction potential
PCE - tetrachloroethene
SW - surface water
TCE - trichloroethene
ug/L - micrograms per liter

Table 4-2
Physiochemical Data and VOCs in North Plume
Site 11 RI
Buckley Air Force Base, Colorado

Well/ Sample No.	Aquifer	Sample Date	TCE (ug/L)	12DCA (ug/L)	CTCL➔ (ug/L)	CHCL3➔ (ug/L)	MECL2 (ug/L)	1,2-Dichloro-propane	Acetone	Benzene	Toluene	p- (or 4-) Isopropyl-toluene	Naphtha-lene	DO (mg/L)	ORP (mV)	pH	Temp (deg. C)	Conduct (mS/cm)
Upgradient to Downgradient																		
11MW04	D	3/24/2009	<0.250	<0.250	<0.250	= 1.20	<0.250	<0.200	= 21.8	<0.125	<0.250	= 0.268 F	<0.200	3.00	168.0	8.75	15.15	3.350
		6/23/2010	= 0.582 F	<0.250	**= 0.626 F**	**= 4.46**	<0.250	<0.200	<2.50	<0.125	<0.250	<0.250	<0.200	1.62	240	6.69	14.60	3.265
1011MW07	D	5/25 & 6/1/06	**= 7.81**	**= 1.50**	**= 7.10**	**= 25.8**	= 0.602 F	<0.200	= 4.05 F	= 0.479	= 0.796 F	<0.250	<0.200	NM	NM	6.77	14.7	2.120
		3/24/2009	**= 61.3**	**= 4.86**	**= 90.7**	**= 78.1**	= 0.463 F	= 0.232 F	<2.50	= 3.97	<0.250	<0.250	<0.200	1.51	80.0	6.88	13.84	3.495
		6/23/2010	**= 65.8**	**= 6.02**	**= 140**	**= 93.8**	= 1.15	= 0.264 F	<2.50	= 1.13	<0.250	<0.250	<0.200	1.47	159.0	6.72	15.0	3.526
11MW15	D	7/1/2010	= 2.39	**= 1.09**	**= 3.67**	**= 17.6**	= 0.446 F	<0.200	= 2.88 F	=0.699	<0.250	<0.250	= 0.240 F	4.47	168.0	7.26	15.5	3.760
1011MW04	D	5/26/2006	<0.250 L	<0.250 L	<0.250 L	<0.125 L	<0.250 L	<0.200 L	= 8.50 F	<0.125 L	<0.250 L	<0.250 L	<0.200 L	NM	NM	8.18	15.4	1.688
		(Dup)	<0.250 L	<0.250 L	<0.250 L	<0.125 L	<0.250 L	<0.200 L	= 6.49 F	<0.125 L	<0.250 L	<0.250 L	<0.200 L					
		6/24/2010	<0.250	<0.250	<0.250	= 0.434	<0.250	<0.200	<2.50	<0.125	<0.250	<0.250	<0.200	1.86	145.0	7.65	15.09	3.358
11MW03	D	3/24/2009	= 0.304 F	<0.250	<0.250	= 1.37	<0.250	<0.200	<2.50	<0.125	<0.250	<0.250	<0.200	7.53	107.1	7.59	12.24	3.528
		6/24/2010	= 0.257 F	<0.250	<0.250	= 0.436	<0.250	<0.200	<2.50	<0.125	<0.250	<0.250	<0.200	1.42	106	7.18	14.10	3.459

➔Degradation pathway

Physiochemical parameters measured using field instruments at the end of purging.

Bolded concentrations exceed CBSGs

A - alluvial
CBSG - Colorado Basic Standards for Groundwater (Regulation 41)
CHCL3 - chloroform
CTCL - carbon tetrachloride
D - Denver Formation
12DCA - 1,2-dichloroethane
deg. C - degrees Celsius
DO - dissolved oxygen
Dup - duplicate sample
F - analyte positively identified but value is below the reporting limit
L - sample analyzed within 1 to 1.5 times the holding time
MECL2 - methylene chloride
mg/L - milligrams per liter
mS/cm - milliSiemens per centimeter
mV - millivolts
NM - not measured
ORP - oxygen reduction potential
TCE - trichloroethene
ug/L - micrograms per liter

Table 5-1
Comparison of Maximum Detected Concentrations in On-Base Groundwater in the PCE Plume to Screening Levels
Site 11 RI, Buckley Air Force Base, Colorado

On-Base PCE Plume - Detected Chemical	CAS No.	Number of Detects	Number of Samples	Percent Detected	Minimum Detected Concentration in Groundwater (µg/L)	Maximum Detected Concentration in Groundwater (µg/L)	EPA RSL (Based on Cancer Risk of 1E-06) (µg/L)[1]	EPA RSL (Based on Non-cancer HQ of 0.1) (µg/L)[1]	EPA MCL (µg/L)[1]	CDPHE Water Std. (µg/L)[2]	Assumed Screening Level (µg/L)[3]	Maximum Detected Concentration Exceeds Screening Level?	COPC?
Acetone	67-64-1	2	32	6.3%	3.51	9.03	--	2200	--	6300	2200	No	No
Bromodichloromethane	75-27-4	6	32	18.8%	0.276	0.721	0.12	73	80	0.56	0.12	Yes	**Yes**
Carbon tetrachloride	56-23-5	1	32	3.1%	0.283	0.283	0.44	8.6	5	0.27	0.27	Yes	**Yes**
Chloroform	67-66-3	15	63	23.8%	0.128	1.15	0.19	13	80	3.5	0.19	Yes	**Yes**
p-Cymene (p-Isopropyltoluene)	99-87-6	1	32	3.1%	1.34	1.34	--	68[4]	--	700	68	No	No
cis-1,2-Dichloroethene	156-59-2	4	63	6.3%	0.361	0.636	--	37	70	70	37	No	No
Naphthalene	91-20-3	1	32	3.1%	0.419	0.419	0.14	0.62	--	140	0.14	Yes	**Yes**
Tetrachloroethene	127-18-4	36	63	57.1%	0.304	108.6	0.11	22	5	5	0.11	Yes	**Yes**
Toluene	108-88-3	1	32	3.1%	0.376	0.376	--	230	1000	560	230	No	No
Trichloroethene	79-01-6	18	63	28.6%	0.291	4.16	2	--	5	5	2	Yes	**Yes**
1,2,4-Trimethylbenzene	95-63-6	1	32	3.1%	0.692	0.692	--	1.5	--	350	1.5	No	No
m,p-Xylene (sum of isomers)	106-42-3/ 108-38-3	1	32	3.1%	0.748	0.748	--	20	10000	1400	20	No	No
o-xylene (1,2-dimethylbenzene)	95-47-6	1	32	3.1%	0.307	0.307	--	120	--	1400	120	No	No

Notes:

[1] RSLs are EPA Regional Screening Levels for Tapwater (May 17, 2010), found at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/Generic_Tables/index.htm

[2] CDPHE water standards are found in Colorado Soil Evaluation Values (CSEV) (12/28/2007), found at: http://www.cdphe.state.co.us/hm/csev.pdf, and Regulation 41, The Basic Standards for Ground Water (11/30/09), found at http://www.cdphe.state.co.us/regulations/wqccregs/100241wqccbasicstandardsforgroundwater.pdf

[3] The selected screening level is the lowest EPA RSL based on a cancer risk of $1x10^{-6}$, RSL based on 0.1 x hazard quotient, the EPA maximum contaminant level (MCL), or the CDPHE Water Standard.

[4] Cumene screening levels used as surrogate.

CDPHE = Colorado Department of Public Health and Environment
COPC = Chemical of Potential Concern
EPA = Environmental Protection Agency
HQ = Hazard Quotient
MCL = Maximum Contaminant Level
RSL = Regional Screening Level
µg/L = micrograms per liter

Table 5-2
Comparison of Maximum Detected Concentrations in
Off-Base Groundwater in the PCE Plume to Screening Levels
Site 11 RI, Buckley Air Force Base, Colorado

Off-Site PCE Plume - Detected Chemical	CAS No.	Number of Detects	Number of Samples	Percent Detected	Minimum Detected Concentration in Groundwater (µg/L)	Maximum Detected Concentration in Groundwater (µg/L)	EPA RSL (Based on Cancer Risk of 1E-06) (µg/L)[1]	EPA RSL (Based on Non-cancer HQ of 0.1) (µg/L)[1]	EPA MCL (µg/L)[1]	CDPHE Water Std. (µg/L)[2]	Assumed Screening Level (µg/L)[3]	Maximum Detected Concentration Exceeds Screening Level?	COPC?
cis-1,2-Dichloroethene	156-59-2	2	49	4.1%	0.62	5.2	--	37	70	70	37	No	No
Tetrachloroethene	127-18-4	38	49	77.6%	0.52	22.0	0.11	22	5	5	0.11	Yes	**Yes**
Trichloroethene	79-01-6	21	49	42.9%	0.63	4.4	2	--	5	5	2	Yes	**Yes**

Notes:

[1] RSLs are EPA Regional Screening Levels for Tapwater (May 17, 2010), found at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/Generic_Tables/index.htm

[2] CDPHE water standards are found in Colorado Soil Evaluation Values (CSEV) (12/28/2007), found at: http://www.cdphe.state.co.us/hm/csev.pdf, and Regulation 41, The Basic Standards for Ground Water (11/30/09), found at http://www.cdphe.state.co.us/regulations/wqccregs/100241wqccbasicstandardsforgroundwater.pdf

[3] The selected screening level is the lowest EPA RSL based on a cancer risk of $1x10^{-6}$, RSL based on 0.1 x hazard quotient, the EPA maximum contaminant level (MCL), or the CDPHE Water Standard.

CDPHE = Colorado Department of Public Health and Environment
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
HQ = Hazard Quotient
MCL = Maximum Contaminant Level
RSL = Regional Screening Level
µg/L = micrograms per liter

Table 5-3
Comparison of Maximum Detected Concentrations in Groundwater in the North Plume to Screening Levels
Site 11 RI, Buckley Air Force Base, Colorado

North Plume - Detected Chemical	CAS No.	Number of Detects	Number of Samples	Percent Detected	Minimum Detected Concentration in Groundwater (µg/L)	Maximum Detected Concentration in Groundwater (µg/L)	EPA RSL (Based on Cancer Risk of 1E-06) (µg/L)[1]	EPA RSL (Based on Non-cancer HQ of 0.1) (µg/L)[1]	EPA MCL (µg/L)[1]	CDPHE Water Std. (µg/L)[2]	Assumed Screening Level (µg/L)[3]	Maximum Detected Concentration Exceeds Screening Level?	COPC ?
Acetone	67-64-1	4	11	36.4%	2.88	21.8	--	2200	--	6300	2200	No	No
Benzene	71-43-2	4	11	36.4%	0.479	3.97	150	4.4	5	5	4.4	No	No
Carbon tetrachloride	56-23-5	5	11	45.5%	0.626	140	0.44	8.6	5	0.27	0.27	Yes	**Yes**
Chloroform	67-66-3	9	11	81.8%	0.434	93.8	0.19	13	80	3.5	0.19	Yes	**Yes**
p-Cymene (p-Isopropyltoluene)	99-87-6	1	11	9.1%	0.268	0.268	--	68[4]	--	700[4]	68	No	No
1,2-Dichloroethane	107-06-2	4	11	36.4%	1.09	6.02	0.15	64	5	0.38	0.15	Yes	**Yes**
1,2-Dichloropropane	78-87-5	2	11	18.2%	0.232	0.264	0.39	0.83	5	0.52	0.39	No	No
Methylene chloride	75-09-2	4	11	36.4%	0.446	1.15	--	37	70	4.7	37	No	No
Naphthalene	91-20-3	1	11	9.1%	0.24	0.24	0.14	1	--	140	0.14	Yes	**Yes**
Trichloroethene	79-01-6	7	11	63.6%	0.257	65.8	2	--	5	5	2	Yes	**Yes**
Toluene	108-88-3	1	11	9.1%	0.796	0.796	--	230	1000	560	230	No	No

Notes:

(1) RSLs are EPA Regional Screening Levels for Tapwater (May 17, 2010), found at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/Generic_Tables/index.ht

(2) CDPHE water standards are found in Colorado Soil Evaluation Values (CSEV) (12/28/2007), found at: http://www.cdphe.state.co.us/hm/csev.pdf, and Regulation 41, The Basic Standards for Ground Water (11/30/09), found at http://www.cdphe.state.co.us/regulations/wqccregs/100241wqccbasicstandardsforgroundwater.pdf

(3) The selected screening level is the lowest EPA RSL based on a cancer risk of $1x10^{6}$, RSL based on 0.1 x hazard quotient, the EPA maximum contaminant level (MCL), or the CDPHE Water Standard.

(4) Cumene screening levels used as surrogate.

CDPHE = Colorado Department of Public Health and Environmen
COPC = Chemical of Potential Concern
EPA = Environmental Protection Agency
HQ = Hazard Quotient
MCL = Maximum Contaminant Leve
RSL = Regional Screening Leve
µg/L = micrograms per liter

Table 5-4
Comparison of Maximum Detected Concentrations in Off-Base Sediment to Screening Levels
Site 11 RI, Buckley Air Force Base, Colorado

Sediment - Detected Chemical	CAS No.	Number of Detects	Number of Samples	Percent Detected	Minimum Detected Concentration in Sediment (mg/kg)	Maximum Detected Concentration in Sediment (mg/kg)	EPA RSL (Based on Cancer Risk of 1E-06) (mg/kg)[1]	EPA RSL (Soil) (Based on Non-cancer HQ of 0.1) (mg/kg)[1]	CDPHE Residential Soil (mg/kg)[2]	Assumed Screening Level (mg/kg)[3]	Maximum Detected Concentration Exceeds Screening Level?	COPC?
cis-1,2-Dichloroethene	156-59-2	1	6	16.7%	2.91E-03	2.91E-03	--	7.8E+01	4.2E+00	4.2E+00	No	No
Trichloroethene	79-01-6	2	3	66.7%	1.15E-03	3.63E-03	2.8E+00	--	3.9E-02	3.9E-02	No	No

Notes:

[1] RSLs are EPA Regional Screening Levels for Residential Soil (May 17, 2010), found at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/Generic_Tables/index.htm

[2] CDPHE soil standards are found in Colorado Soil Evaluation Values (CSEV) (12/28/2007), found at: http://www.cdphe.state.co.us/hm/csev.pdf

[3] The selected screening level is the lowest EPA RSL based on a cancer risk of $1x10^{-6}$, RSL based on 0.1 x hazard quotient, or the CDPHE Residential Soil CSEV.

COPC = Chemical of Potential Concern
CDPHE = Colorado Department of Public Health and Environment
EPA = U.S. Environmental Protection Agency
HQ = Hazard Quotient
mg/kg = milligrams per kilograms
RSL = Regional Screening Level

Table 5-5
Comparison of Maximum Detected Concentrations in Off-Base Surface Water to Screening Levels
Site 11 RI, Buckley Air Force Base, Colorado

Detected Chemical	CAS No.	Number of Detects	Number of Samples	Percent Detected	Minimum Detected Concentration in Surface Water (µg/L)	Maximum Detected Concentration in Surface Water (µg/L)	EPA RSL (Based on Cancer Risk of 1E-06) (µg/L)[1]	EPA RSL (Based on Non-cancer HQ of 0.1) (µg/L)[1]	EPA MCL (µg/L)[1]	CDPHE Water Std. (µg/L)[2]	Assumed Screening Level (µg/L)[2]	Maximum Detected Concentration Exceeds Screening Level?	COPC ?
Tetrachloroethene	127-18-4	3	3	100.0%	3.04E-01	4.70E-01	4.01E-01	0.11	5	3.3	0.11	Yes	**Yes**
Trichloroethene	79-01-6	3	3	100.0%	2.80E-01	3.80E-01	3.20E-01	2	5	5	2	No	No

Notes:
[1] RSLs are EPA Regional Screening Levels for Tapwater (May 17, 2010), found at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
[2] CDPHE water standards are found in Colorado Soil Evaluation Values (CSEV) (12/28/2007), found at: http://www.cdphe.state.co.us/hm/csev.pdf, and Regulation 31, The Basic Standards and Methodologies for Surface Water (11/30/09), found at http://www.cdphe.state.co.us/regulations/wqccregs/100231wqccbasicstandardsforsurfacewater.pdf; the lowest is listed.
[3] The selected screening level is the lowest EPA RSL based on a cancer risk of $1x10^{-6}$, RSL based on 0.1 x hazard quotient, the EPA maximum contaminant level (MCL), or the CDPHE Water Standard.
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
HQ = Hazard Quotient

RSL = Regional Screening Level
µg/L = micrograms per liter

Table 5-6
Evaluation of Maximum Detected Concentrations in
On-Base PCE Plume Groundwater for Vapor Intrusion into Buildings
Site 11 RI, Buckley Air Force Base, Colorado

Detected Chemical	CAS No.	Maximum Detected Concentration in Groundwater (µg/L)	Location of Maximum Concentration	Sampling Date	Target Groundwater Concentration (µg/L) [1]	Basis	Maximum Detected Concentration Exceeds Screening Level?	COPC?
1,2,4-Trimethylbenzene	95-63-6	0.692	11MW16 (avg)[2]	Jun-25-2010	2	NC	No	No
Acetone	67-64-1	9.03	11MW05 (avg)	Mar-23-2009	22000	NC	No	No
Bromodichloromethane	75-27-4	0.721	11MW07	Jun-24-2010	21	C	No	No
Carbon tetrachloride	56-23-5	0.283	11MW11	Jul-08-2009	5	MCL	No	No
Chloroform	67-66-3	1.15	11MW07	Jun-24-2010	80	C	No	No
cis-1,2-Dichloroethene	156-59-2	0.636	1011MW06	Jun-01-2006	21	NC	No	No
m,p-Xylene (sum of isomers)	106-42-3/ 108-38-3	0.748	11MW16 (avg)	Jun-25-2010	2200	NC	No	No
Naphthalene	91-20-3	0.419	11MW16 (avg)	Jun-25-2010	15	NC	No	No
o-xylene (1,2-dimethylbenzene)	95-47-6	0.307	11MW16 (avg)	Jun-25-2010	3300	NC	No	No
p-Cymene (p-Isopropyltoluene)	99-87-6	1.335	11MW05 (avg)	Mar-23-2009	0.8	NC	Yes	No
Tetrachloroethene	127-18-4	108.6	11MW05 (avg)	Jul-7-2009	5	MCL	**Yes**	**Yes**
Toluene	108-88-3	0.376	11MW16 (avg)	Jun-25-2010	150	NC	No	No
Trichloroethene	79-01-6	4.16	11MW06	Jun-24-2010	5	MCL	No	No

Notes:

[1] Screening level based on cancer risk of $1x10^{-6}$, non-cancer risk (HI) of 0.1, or MCL from Table 2c, "Question 4, Generic Screening Level and Summary Sheet - Risk $1x10^{-6}$" (EPA, 2002)

[2] "avg" indicated that the values is an average of duplicate samples.

C = Cancer
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
MCL = Maximum Contaminant Level
NC = Non-cancer
µg/L = micrograms per liter

Table 5-7
Evaluation of Maximum Detected Concentrations in
Off-Base PCE Plume Groundwater for Vapor Intrusion into Buildings
Site 11 RI, Buckley Air Force Base, Colorado

Detected Chemical	CAS No.	Maximum Detected Concentration in Groundwater (µg/L)	Location of Maximum Concentration	Sampling Date	Target Groundwater Concentration (µg/L)[1]	Basis	Maximum Detected Concentration Exceeds Screening Level?	COPC?
cis-1,2-Dichloroethene	156-59-2	5.20E+00	11DP65	5/26/2010	21	NC	No	No
Tetrachloroethene	127-18-4	2.20E+01	11DP57	5/26/2010	5	MCL	Yes	**Yes**
Trichloroethene	79-01-6	4.40E+00	11DP43	2/18/2010	5	MCL	No	No

Notes:

[1] Screening level based on cancer risk of $1x10^{-6}$, non-cancer risk (HI) of 0.1, or MCL from Table 2c, "Question 4, Generic Screening Level and Summary Sheet - Risk $1x10^{-6}$" (EPA, 2002)

COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
MCL = Maximum Contaminant Level
NC = Non-cancer
µg/L = micrograms per liter

Table 5-8
Evaluation of Maximum Detected Concentrations in
North Plume Groundwater for Vapor Intrusion into Buildings
Site 11 RI, Buckley Air Force Base, Colorado

Detected Chemical	CAS No.	Maximum Detected Concentration in Groundwater (µg/L)	Location of Maximum Concentration	Sampling Date	Target Groundwater Concentration (µg/L)[1]	Basis	Maximum Detected Concentration Exceeds Screening Level?	COPC?
1,2-Dichloroethane	107-06-2	6.02	1011MW07	Jun-23-2010	5	MCL	**Yes**	**Yes**
1,2-Dichloropropane	78-87-5	0.264	1011MW07	Jun-23-2010	3.5	NC	No	No
Acetone	67-64-1	21.8	11MW04	Mar-24-2009	22000	NC	No	No
Benzene	71-43-2	3.97	1011MW07	Mar-24-2009	5	MCL	No	No
Carbon tetrachloride	56-23-5	140	1011MW07	Jun-23-2010	5	MCL	**Yes**	**Yes**
Chloroform	67-66-3	93.8	1011MW07	Jun-23-2010	80	C	**Yes**	**Yes**
Methylene chloride	75-09-2	1.15	1011MW07	Jun-23-2010	58	C	No	No
Naphthalene	91-20-3	0.24	11MW15	Jul-01-2010	15	NC	No	No
p-Cymene (p-Isopropyltoluene)	99-87-6	0.268	11MW04	Mar-24-2009	0.8	NC	No	No
Toluene	108-88-3	0.796	1011MW07	Jun-01-2006	150	NC	No	No
Trichloroethene	79-01-6	65.8	1011MW07	Jun-23-2010	5	MCL	**Yes**	**Yes**

Notes:

[1] Screening level based on cancer risk of $1x10^{-6}$, non-cancer risk (HI) of 0.1, or MCL from Table 2c, "Question 4, Generic Screening Level and Summary Sheet - Risk $1x10^{-6}$" (EPA, 2002)

C = Cancer
COPC = Chemical of Potential Concern
EPA = U.S. Environmental Protection Agency
MCL = Maximum Contaminant Level
NC = Non-cancer
µg/L = micrograms per liter

Table 5-9
Chemicals of Potential Concern
Groundwater, Surface Water, and Sediment
Site 11 RI, Buckley Air Force Base, Aurora, Colorado

COPC	On-Base PCE Plume	Off-Base PCE Plume	North Plume	Off Base	
				Surface Water	Sediment
	Groundwater	Groundwater	Groundwater		
1,2-Dichloroethane			X		
Bromodichloromethane	X				
Carbon tetrachloride	X		X		
Chloroform	X		X		
cis-1,2-Dichloroethylene					
Naphthalene	X		X		
Tetrachloroethene	X	X		X	
Trichloroethene	X	X	X		

Notes:
COPC = Chemical of Potential Concern
PCE = Tetrachloroethene

Table 5-10
Selection of Exposure Pathways
Site 11 RI, Buckley Air Force Base, Colorado

Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
groundwater	groundwater	water supply well - tap	Commercial Worker	adult	ingestion	on-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
					dermal	on-site	none	Based on the short duration and small area of exposed skin surface, dermal absorption is not anticipated to be a significant pathway for this receptor; therefore, pathway not selected for evaluation.
	air	volatilized chemicals enter indoor air through slab			inhalation	on-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
groundwater	groundwater	groundwater at excavation site	Construction/ Utility Worker	adult	ingestion	on-site	none	Based on depth to groundwater, this is not a complete pathway and was not selected for evaluation.
						off-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
					dermal	on-site	none	Based on depth to groundwater, this is not a complete pathway and was not selected for evaluation.
						off-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
	air	air volatilized from groundwater in trench at excavation site			inhalation	on-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
						off-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
sediment	sediment	East Toll Gate Creek Sediment	Maintenance Worker	adult	ingestion	off-site	none	Pathway potentially complete, but no COPCs identified; pathway not evaluated.
					dermal		none	Pathway potentially complete, but no COPCs identified; pathway not evaluated.
surface water	surface water	East Toll Gate Creek Surface Water			ingestion		quantitative	Pathway potentially complete; selected for quantitative evaluation.
					dermal		quantitative	Pathway potentially complete; selected for quantitative evaluation.
groundwater	groundwater	water supply well - tap water	Resident	adult/child	ingestion	on-site and off-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
					dermal		quantitative	Pathway potentially complete; selected for quantitative evaluation.
	air	volatilized chemicals enter indoor air through slab			inhalation		quantitative	Pathway potentially complete; selected for quantitative evaluation.
sediment	sediment	East Toll Gate Creek Sediment	Visitor	youth	ingestion	off-site	none	Pathway potentially complete, but no COPCs identified; pathway not evaluated.
					dermal		none	Pathway potentially complete, but no COPCs identified; pathway not evaluated.
surface water	surface water	East Toll Gate Creek Surface Water			ingestion	off-site	quantitative	Pathway potentially complete; selected for quantitative evaluation.
					dermal		quantitative	Pathway potentially complete; selected for quantitative evaluation.

Table 5-11
Input Parameters for Johnson and Ettinger Model for On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Variable	Value
Average soil temperature (ºC)[1]	10
Depth below grade to bottom of enclosed space floor (cm)[2]	200
Groundwater sampling depth, below grade[3]	735.2
Thickness of soil stratum A, cm[4]	304.8
SCS soil type, stratum A[4]	SI
Dry bulk density (g/cm^3), stratum A[5]	1.35
Total porosity (unitless), stratum A[5]	0.489
Water-filled porosity (g/cm^3), stratum A[5]	0.167
Thickness of soil stratum B, cm[4]	430.4
SCS soil type, stratum B[4]	CL
Dry bulk density (g/cm^3), stratum B[6]	1.48
Total porosity (unitless), stratum B[6]	0.442
Water-filled porosity (g/cm^3), stratum B[6]	0.168
Enclosed space floor thickness (cm)[2]	10
Soil-building pressure differential ($g/cm\text{-}s^2$)[2]	40
Enclosed space floor length (cm)[2]	1000
Enclosed space floor width (cm)[2]	1000
Enclosed space height (cm)[2]	366
Floor-wall seam crack width (cm)[2]	0.1
Indoor air exchange rate (L/hr)[2]	0.25
Average vapor flow rate into building (L/minute)[1]	5

Notes:
[1] Default model value (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)
[2] Default model values for residence with a basement
[3] Approximate depth to groundwater in source area of 24.12 feet (735.18 cm) based on June 2010 depth of Well 11MW05.
[4] In the source area, the soil was assumed to consist of two layers: silt from the surface to 10 feet bgs, and silt loam from 10 feet bgs to groundwater. Therefore, the thickness of soil stratum A was set to 10 feet and the thickness of soil stratum B was set at 14.12 feet based on a groundwater depth of 24.12 feet.
[5] Model default values for dry bulk density, total porosity, and water-filled porosity for silt
[6] Model default values for dry bulk density, total porosity, and water-filled porosity for silty loam
ºC = degrees Celsius
cm = centimeter
g/cm^3 = grams per cubic centimeter
$g/cm\text{-}s^2$ = grams per centimeter - seconds squared
L/hr = liter per hour
L/minute = liters per minute
SCS = Soil Conservation Survey

Table 5-12
Input Parameters for Johnson and Ettinger Model for Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Variable	Value
Average soil temperature (ºC)[1]	10
Depth below grade to bottom of enclosed space floor (cm)[2]	274.3
Groundwater sampling depth, below grade[3]	274.3
Thickness of soil stratum A, cm[4]	213.4
SCS soil type, stratum A[4]	C
Dry bulk density (g/cm^3), stratum A[5]	1.43
Total porosity (unitless), stratum A[5]	0.459
Water-filled porosity (g/cm^3), stratum A[5]	0.215
Thickness of soil stratum B, cm[4]	61.0
SCS soil type, stratum B[4]	LS
Dry bulk density (g/cm^3), stratum B[6]	1.62
Total porosity (unitless), stratum B[6]	0.39
Water-filled porosity (g/cm^3), stratum B[6]	0.076
Enclosed space floor thickness (cm)[2]	10
Soil-building pressure differential ($g/cm\text{-}s^2$)[2]	40
Enclosed space floor length (cm)[2]	1000
Enclosed space floor width (cm)[2]	1000
Enclosed space height (cm)[2]	366
Floor-wall seam crack width (cm)[2]	0.1
Indoor air exchange rate (L/hr)[2]	0.25
Average vapor flow rate into building (L/minute)[1]	5

Notes:
[1] Default model value (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)
[2] Default model values for residence with a basement
[3] Approximate depth to groundwater in off-base PCE Plume of 9 feet (274.3 cm) based on July 2009 and June 2010 depths of Well 11MW12.
[4] In the off-base PCE Plume, based on well 11MW12 which is less than 10 feet from the base boundary, the soil was assumed to consist of two layers: clay from the surface to 7 feet bgs, and loamy sand from 7 feet bgs to groundwater. Therefore, the thickness of soil stratum A was set to 7 feet and the thickness of soil stratum B was set at 2 feet based on a groundwater depth of 9 feet bgs.
[5] Model default values for dry bulk density, total porosity, and water-filled porosity for clay.
[6] Model default values for dry bulk density, total porosity, and water-filled porosity for loamy sand.
ºC = degrees Celsius
bgs = below ground surface
cm = centimeter
g/cm^3 = grams per cubic centimeter
$g/cm\text{-}s^2$ = grams per centimeter - seconds squared
L/hr = liter per hour
L/minute = liters per minute
SCS = Soil Conservation Survey

Table 5-13
Input Parameters for Johnson and Ettinger Model for North Plume
Site 11 RI, Buckley Air Force Base, Colorado

Variable	Value
Average soil temperature (ºC)[1]	10
Depth below grade to bottom of enclosed space floor (cm)[2]	200
Groundwater sampling depth, below grade[3]	718.1
Thickness of soil stratum A, cm[4]	396.24
SCS soil type, stratum A[4]	S
Dry bulk density (g/cm^3), stratum A[5]	1.66
Total porosity (unitless), stratum A[5]	0.375
Water-filled porosity (g/cm^3), stratum A[5]	0.054
Thickness of soil stratum B, cm[4]	152.4
SCS soil type, stratum B[4]	SC
Dry bulk density (g/cm^3), stratum B[6]	1.63
Total porosity (unitless), stratum B[6]	0.385
Water-filled porosity (g/cm^3), stratum B[6]	0.197
Thickness of soil stratum C, cm[4]	169.5
SCS soil type, stratum C[4]	C
Dry bulk density (g/cm^3), stratum C[7]	1.43
Total porosity (unitless), stratum C[7]	0.459
Water-filled porosity (g/cm^3), stratum C[7]	0.215
Enclosed space floor thickness (cm)[2]	10
Soil-building pressure differential ($g/cm\text{-}s^2$)[2]	40
Enclosed space floor length (cm)[2]	1000
Enclosed space floor width (cm)[2]	1000
Enclosed space height (cm)[2]	366
Floor-wall seam crack width (cm)[2]	0.1
Indoor air exchange rate (L/hr)[2]	0.25
Average vapor flow rate into building (L/minute)[1]	5

Notes:
[1] Default model value (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)
[2] Default model values for residence with a basement
[3] Approximate depth to groundwater in source area of 23.56 feet (718.11 cm) based on June 2010 depth of Well 1011MW07.
[4] In the source area, the soil was assumed to consist of three layers: sand from the surface to 13 feet bgs, and sandy clay from 13 to 18 feet bgs, and clay from 18 feet bgs to groundwater. Therefore, the thickness of soil stratum A was set to 13 feet, the thickness of soil stratum B was set at 5 feet, and the thickness of stratum C was set at 5.56 feet, based on a groundwater depth of 23.56 feet.
[5] Model default values for dry bulk density, total porosity, and water-filled porosity for sand
[6] Model default values for dry bulk density, total porosity, and water-filled porosity for sandy clay
[7] Model default values for dry bulk density, total porosity, and water-filled porosity for clay
ºC = degrees Celsius
cm = centimeter
g/cm^3 = grams per cubic centimeter
$g/cm\text{-}s^2$ = grams per centimeter - seconds squared
L/hr = liter per hour
L/minute = liters per minute
SCS = Soil Conservation Survey

Table 5-14
Predicted Indoor Air Concentrations for Groundwater COPCs for the On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	Maximum Detected Concentration in Groundwater (µg/L)	Sampling Location	Predicted Source Vapor Concentration (µg/m^3)[1]	Infinite Source Indoor Attenuation Coefficent (unitless)[1]	Predicted Indoor Air Concentration (µg/m^3)
Bromodichloromethane	0.721	11MW07	3.17E+01	7.64E-05	1.74E-03
Carbon tetrachloride	0.283	11MW11	6.46E+02	1.15E-04	2.11E-02
Chloroform	1.15	11MW07	8.02E+01	1.63E-04	1.50E-02
Naphthalene	0.419	11MW16 (avg)[2]	6.54E+00	1.82E-04	4.98E-04
Tetrachloroethene	108.6	11MW05 (avg)	3.36E+02	1.08E-04	3.94E+00
Trichloroethene	4.16	11MW06	2.06E+02	1.20E-04	1.03E-01

Notes:
[1] As predicted by EPA's model (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)
[2] "avg" indicated that the values is an average of duplicate samples.

EPA = U.S. Environmental Protection Agency
MW = Monitoring Well
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-15
Predicted Indoor Air Concentrations for Groundwater COPCs for the Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	Maximum Detected Concentration in Groundwater (µg/L)	Sampling Location	Predicted Source Vapor Concentration ($\mu g/m^3$)[(1)]	Infinite Source Indoor Attenuation Coefficent[(1)]	Predicted Indoor Air Concentration ($\mu g/m^3$)
Tetrachloroethene	22	11DP57	3.36E+02	4.43E-04	3.28E+00
Trichloroethene	4.4	11DP43	2.06E+02	4.85E-04	4.39E-01

Notes:
[(1)]As predicted by EPA's model (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)

bgs = below ground surface
EPA = Environmental Protection Agency
MW = Monitoring Well
µg/L = micrograms per Liter
$\mu g/m^3$ = micrograms per cubic meter

Table 5-16
Predicted Indoor Air Concentrations for Groundwater COPCs for the North Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	Maximum Detected Concentration in Groundwater (µg/L)	Sampling Location	Predicted Source Vapor Concentration (µg/m^3)[(1)]	Infinite Source Indoor Attenuation Coefficent[(1)]	Predicted Indoor Air Concentration (µg/m^3)
1,2-Dichloroethane	6.02	1011MW07	1.96E+01	1.05E-04	1.24E-02
Carbon tetrachloride	140	1011MW07	6.46E+02	1.48E-05	1.34E+00
Chloroform	93.8	1011MW07	8.02E+01	4.05E-05	3.05E-01
Naphthalene	0.240	11MW15	6.54E+00	1.57E-04	2.46E-04
Trichloroethene	65.8	1011MW07	2.06E+02	4.33E-03	5.87E+01

Notes:
[(1)]As predicted by EPA's model (GW-ADV, Version 3.1, 02/2004 - http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm)

COPC = Chemical of Potential Concern
EPA = Environmental Protection Agency
MW = Monitoring Well
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-17
Calculation of Exposure Point Concentrations for
Inhalation of Chemicals from Groundwater in a Trench - On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	CAS No.	Molecular Weight MWi (g/mol)	Henry's Law Constant Hi (atm-m^3/mol)	Diffusion Coefficient in Air Dair (cm^2/s)	Concentration of Contaminant in Groundwater Cgw (ug/L)	Volatilization Factor VF (L/m^3)	Concentration of Contaminant in Trench Ctrench (ug/m^3)	Concentration of Contaminant in Trench Ctrench (mg/m^3)
Bromodichloromethane	75-27-4	163.83	1.60E-03	5.63E-02	7.21E-01	2.69E-03	1.94E-03	1.94E-06
Carbon tetrachloride	56-23-5	153.82	3.04E-02	7.80E-02	2.83E-01	7.08E-02	2.00E-02	2.00E-05
Chloroform	67-66-3	119.38	3.67E-03	1.04E-01	1.15E+00	1.14E-02	1.31E-02	1.31E-05
Naphthalene	91-20-3	128.17	4.83E-04	5.90E-02	4.19E-01	3.96E-02	1.66E-02	1.66E-05
Tetrachloroethene	127-18-4	165.83	1.84E-02	7.20E-02	1.09E+02	2.43E-02	2.64E+00	2.64E-03
Trichloroethene	79-01-6	131.39	1.03E-02	7.90E-02	4.16E+00	8.51E-04	3.54E-03	3.54E-06

Notes:
Source: Spreadsheet from Virginia Department of Environmental Quality - Table 3.7, Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater greater than 15 feet deep. Accessed at: http://www.deq.state.va.us/vrprisk/tables.html

atm-m^3/mol = atmospheres-cubic meters per mole
cm^2/s = square centimeters per second
COPC = Chemical of Potential Concern
g/mol = grams per mole
L/m^3 = liters per cubic meter
mg/m^3 = milligrams per cubic meter
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-18
Calculation of Exposure Point Concentrations for
Inhalation of Chemicals from Groundwater in a Trench - Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	CAS No.	Molecular Weight MWi (g/mol)	Henry's Law Constant Hi (atm-m^3/mol)	Gas-Phase Mass Transfer Coefficient KiG (cm/s)	Liquid-Phase Mass Transfer Coefficient KiL (cm/s)	Overall Mass Transfer Coefficient Ki (cm/s)	Concentration of Contaminant in Groundwater Cgw (µg/L)	Volatilization Factor VF (L/m^3)	Concentration of Contaminant in Trench Ctrench (µg/m^3)	Concentration of Contaminant in Trench Ctrench (mg/m^3)
Tetrachloroethene	127-18-4	165.83	1.84E-02	3.96E-01	8.79E-04	8.76E-04	2.20E+01	6.47E+00	1.42E+02	1.42E-01
Trichloroethene	79-01-6	131.39	1.03E-02	4.28E-01	9.87E-04	9.82E-04	4.40E+00	7.25E+00	3.19E+01	3.19E-02

Notes:
Source: Spreadsheet from Virginia Department of Environmental Quality - Table 3.8, Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less than 15 feet deep (spreadsheet) (revised 10/5/07). Accessed at: http://www.deq.state.va.us/vrprisk/tables.htm

atm-m^3/mol = atmospheres-cubic meters per mole
cm/s = centimeters per second
COPC = Chemical of Potential Concern
g/mol = grams per mole
L/m^3 = liters per cubic meter
mg/m^3 = milligrams per cubic meter
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-19
Calculation of Exposure Point Concentrations for
Inhalation of Chemicals from Groundwater in a Trench - North Plume
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	CAS No.	Molecular Weight MWi (g/mol)	Henry's Law Constant Hi (atm-m^3/mol)	Diffusion Coefficient in Air Dair (cm^2/s)	Concentration of Contaminant in Groundwater Cgw (µg/L)	Volatilization Factor VF (L/m^3)	Concentration of Contaminant in Trench Ctrench (µg/m^3)	Concentration of Contaminant in Trench Ctrench (mg/m^3)
Carbon tetrachloride	56-23-5	153.82	3.04E-02	7.80E-02	1.40E+02	6.37E-01	8.92E+01	8.92E-02
Chloroform	67-66-3	119.38	3.67E-03	1.04E-01	9.38E+01	1.03E-01	9.62E+00	9.62E-03
1,2-Dichloroethane	107-06-2	98.96	9.79E-04	1.04E-01	6.02E+00	2.74E-02	1.65E-01	1.65E-04
Naphthalene	91-20-3	128.17	4.83E-04	5.90E-02	2.40E-01	7.66E-03	1.84E-03	1.84E-06
Trichloroethene	79-01-6	131.39	1.03E-02	7.90E-02	6.58E+01	2.19E-01	1.44E+01	1.44E-02

Notes:
Source: Table 3.7 Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater greater than 15 feet deep
http://www.deq.state.va.us/vrprisk/tables.html

atm-m^3/mol = atmospheres-cubic meters per mole
cm^2/s = square centimeters per second
COPC = Chemical of Potential Concern
g/mol = grams per mole
L/m^3 = liters per cubic meter
mg/m^3 = milligrams per cubic meter
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-20
Exposure Point Concentration Summary
Site 11 RI, Buckley Air Force Base, Colorado

Groundwater COPC	Groundwater			Indoor Air			Trench Air			Surface Water	Sediment
	On-Base PCE Plume (µg/L)	Off-Base PCE Plume (µg/L)	North Plume (µg/L)	On-Base PCE Plume (µg/m^3)	Off-Base PCE Plume (µg/m^3)	North Plume (µg/m^3)	On-Base PCE Plume (mg/m^3)	Off-Base PCE Plume (mg/m^3)	North Plume (mg/m^3)	(µg/L)	(mg/kg)
Bromodichloromethane	7.21E-01	ND	ND	1.74E-03	ND	ND	1.94E-06	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	6.02E+00	ND	ND	1.24E-02	ND	ND	1.65E-04	ND	ND
Carbon tetrachloride	2.83E-01	ND	1.40E+02	2.11E-02	ND	1.34E+00	2.00E-05	ND	8.92E-02	ND	ND
Chloroform	1.15E+00	ND	9.38E+01	1.50E-02	ND	3.05E-01	1.31E-05	ND	9.62E-03	ND	ND
Naphthalene	4.19E-01	ND	2.40E-01	4.98E-04	ND	2.46E-04	1.66E-05	ND	1.84E-06	ND	ND
Tetrachloroethene	1.09E+02	2.20E+01	ND	3.94E+00	3.28E+00	ND	2.64E-03	1.42E-01	ND	4.7E-01	ND
Trichloroethene	4.16E+00	4.40E+00	6.58E+01	1.03E-01	4.39E-01	5.87E+01	3.54E-06	3.19E-02	1.44E-02	NA	NA

Notes:
NA = not applicable - not selected as a COPC
ND = not detected

COPC - chemical of potential concern.
mg/kg - milligrams per kilogram.
mg/m^3 = milligrams per cubic meter
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table 5-21
Values Used for Daily Intake Calculations
Ingestion of Groundwater by Commercial Workers, Construction Workers, and Residents
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timeframe:	Future
Receptor:	Commercial Worker, Adult
	Construction Worker, Adult
	Resident, Adult
	Resident, Child
Medium:	Groundwater
Exposure Medium:	Groundwater

Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Commercial Worker	Adult	Tap Water	EPC	Exposure point concentration	Chemical-specific	µg/L		Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-G	Ingestion rate of groundwater	2	L/day	EPA, 2002	EPC X IR-G X EF X ED X CF X 1/BW x 1/AT
				CF	Conversion factor	1.00E-03	mg/µg	--	
				EF	Exposure frequency	250	days/year	EPA, 2002	
				ED	Exposure duration	25	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	9,125	days	EPA, 2002	
	Construction Worker	Adult	Trench Water	EPC	Exposure point concentration	Chemical-specific	µg/L		Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-G	Ingestion rate of groundwater	0.02	L/day	Incidental ingestion - Professional judgement (1)	EPC X IR-G X EF X ED X CF X 1/BW x 1/AT
				CF	Conversion factor	1.00E-03	mg/µg	--	
				EF	Exposure frequency	120	days/year	Professional judgement	
				ED	Exposure duration	0.5	years	Professional judgement	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	183	days	EPA, 2002	
	Resident	Adult	Tap Water	EPC	Exposure point concentration	Chemical-specific	µg/L		Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-G	Ingestion rate of groundwater	2	L/day	EPA, 2002	EPC X IR-G X EF X ED X CF X 1/BW x 1/AT
				CF	Conversion factor	1.00E-03	mg/µg	--	
				EF	Exposure frequency	350	days/year	EPA, 2002	
				ED	Exposure duration	24	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	8,760	days	EPA, 2002	
		Child	Tap Water	EPC	Exposure point concentration	Chemical-specific	µg/L		Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-G	Ingestion rate of groundwater	1	L/day	EPA, 2002	EPC X IR-G X EF X ED X CF X 1/BW x 1/AT
				CF	Conversion factor	1.00E-03	mg/µg	--	
				EF	Exposure frequency	350	days/year	EPA, 2002	
				ED	Exposure duration	6	years	EPA, 2002	
				BW	Body weight	15	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 2002	

Notes:
(1) Ingestion of groundwater while working in a trench would be expected to be minimal. The assumed value, 0.02 L/day, is 10% of the adult water ingestion rate of 2 L/day.

References:
EPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

kg = kilograms
L/day = liters per day
mg/µg - milligrams per microgram
µg/L = micrograms per liter

Table 5-22
Values Used for Daily Dermal Intake Calculations
Constuction Worker and Residents Exposure to Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timeframe:	Future
Receptor:	Construction Worker, Adult
	Resident, Adult
	Resident, Child
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Construction Worker	Adult	Groundwater from Trench	SA	Skin surface area available for contact	3,300	cm^2	EPA, 2002	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA_{EVENT} x EV X SA X EF X ED X1/BW x 1/AT
				DA_{EVENT}	Absorbed dose per event	Chemical-specific	mg/cm^2-event		
				EV	Event frequency	1	event/day	EPA, 2002	
				EF	Exposure frequency	120	days/year	Professional Judgement	
				ED	Exposure duration	1	years	Professional Judgement	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	183	days	EPA, 2002	
	Resident	Adult	Tap Water	SA	Skin surface area available for contact	3,300	cm^2	EPA, 2002	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA_{EVENT} x EV X SA X EF X ED X1/BW x 1/AT
				DA_{EVENT}	Absorbed dose per event	Chemical-specific	mg/cm^2-event		
				EV	Event frequency	1	event/day	EPA, 2002	
				EF	Exposure frequency	350	days/year	EPA, 2002	
				ED	Exposure duration	24	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	8,760	days	EPA, 2002	
	Resident	Child	Tap Water	SA	Skin surface area available for contact	3,300	cm^2	EPA, 2002	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA_{EVENT} x EV X SA X EF X ED X1/BW x 1/AT
				DA_{EVENT}	Absorbed dose per event	Chemical-specific	mg/cm^2-event		
				EV	Event frequency	1	event/day	EPA, 2002	
				EF	Exposure frequency	350	days/year	EPA, 2002	
				ED	Exposure duration	6	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 2002	
	All Receptors			FA	Fraction absorbed water	Chemical-specific	unitless	App. B, EPA 2004	If $t_{event} \leq t^*$, then : DA_{event} (Organic) = $2\,FA \times K_p \times C_w \sqrt{\frac{6\,\tau_{event} \times t_{event}}{\pi}}$ If $t_{event} > t^*$, then : DA_{event} (Organic) = $FA \times K_p \times C_w \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
				Kp	Dermal permeability coefficient	Chemical-specific	cm/hour	App. B, EPA 2004	
				Cw	Chemical concentration in water	Chemical-specific	µg/L	App. B, EPA 2004	
				CF1	Conversion factor	1.00E-03	mg/µg	--	
				CF2	Conversion factor	1.00E-03	L/cm^3	--	
				B	Ratio of Permeability Coefficient	Chemical-specific	unitless	App. B, EPA 2004	
				t*	Time to reach steady state	Chemical-specific	hour	App. B, EPA 2004	
				τevent	Lag time per event	Chemical-specific	hr/event	App. B, EPA 2004	
				tevent	Event duration - construction worker	2.00	hr/event	EPA, 2004	
					Event duration - resident, adult	0.58	hr/event	EPA, 2004	
					Event duration - resident, child	1	hr/event	EPA, 2004	

References:

EPA, 2002 Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

EPA, 2004 Risk Assessment Guidance for Superfund (RAGS). Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).

cm^2 = square centimeters
cm/hour = centimeters per hour
g/cm^2-event = grams per square centimeters-event
kg = kilograms
L/cm^3 = liters per cubic centimeter
mg/µg - milligrams per microgram
µg/L = micrograms per liter

Table 5-23
Values Used for Daily Intake Calculations
Inhalation of Volatiles in Indoor Air from Vapor Intrusion from Groundwater
Adult and Child Resident and Commercial Worker
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timefra	Future
Receptor:	Resident, Child
	Resident, Adult
	Commercial Worker, Adult
Medium:	Groundwater
Exposure Mediun	Air (Indoor)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Indoor Air - Vapor Intrusion from Groundwater	CA	Contaminant concentration in air	Chemical-specific	µg/m^3	Modeled concentration	Exposure concentration (EC) (µg/m^3) = CA x ET x EF x ED x 1/AT
				ET	Exposure time	24	hours/day	EPA, 2002	
				EF	Exposure frequency	350	days/yr	EPA, 2002	
				ED	Exposure duration	24	years	EPA, 2002	
				AT-C	Averaging Time (Cancer)	613,200	hour	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	210,240	hour	EPA, 2002	
		Child	Indoor Air - Vapor Intrusion from Groundwater	EPC	Chemical concentration in air	Chemical-specific	µg/m^3	Modeled concentration	Exposure concentration (EC) (µg/m^3) = CA x ET x EF x ED x 1/AT
				ET	Exposure time	24	hours/day	EPA, 2002	
				EF	Exposure frequency	350	days/year	EPA, 2002	
				ED	Exposure duration	6	years	EPA, 2002	
				AT-C	Averaging Time (Cancer)	613,200	hour	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	52,560	hour	EPA, 2002	
	Commercial Worker	Adult	Indoor Air - Vapor Intrusion from Groundwater	EPC	Chemical concentration in air	Chemical-specific	µg/m^3	Modeled concentration	Exposure concentration (EC) (µg/m^3) = CA x ET x EF x ED x 1/AT
				ET	Exposure time	8	hours/day	EPA, 2002	
				EF	Exposure frequency	250	days/year	EPA, 2002	
				ED	Exposure duration	25	years	EPA, 2002	
				AT-C	Averaging Time (Cancer)	613,200	hour	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	219,000	hour	EPA, 2002	

References:
EPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

mg/m^3 - milligrams per cubic meter
µg/m^3 = micrograms per cubic meter

Table 5-24
Values Used for Daily Intake Calculations Construction Worker by Inhalation of Volatiles from Groundwater in a Trench
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timeframe:	Future
Receptor:	Construction Worker, Adult
Medium:	Groundwater
Exposure Medium:	Air (Trench)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Construction Worker	Adult	Vapor from Trench	ET	Exposure time	8	hours/day		Exposure concentration (EC) ($\mu g/m^3$) = Ctrench x ET x EF x ED x 1/AT
				EF	Exposure frequency	250	days/year	Professional Judgement	
				ED	Exposure duration	1	years	Professional Judgement	
				AT-C	Averaging Time (Cancer)	613,200	hour	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	8760	hour	EPA, 2002	
				Ctrench	Concentration of contaminant in the trench air	Site-specific	$\mu g/m^3$	calculated	Ctrench (ug/m^3) = CGW x VF
				CGW	Concentration of contaminant in groundwater	Site-specific	µg/L	site-specific	
				VF	Volatilization factor	Chemical-specific	L/m^3	VDEQ, 2007	
				Ki	Overall mass transfer coefficient of contaminant	Chemical-specific	cm/s	VDEQ, 2007	Volatilization factor (VF) (L/m^3) =
				A	Area of the trench	2.44	m^2	VDEQ, 2007	(Ki x A x F x 10-3 x 104 x 3600) / (ACH xV)
				F	Fraction of the floor through which contaminant can enter	1	unitless	VDEQ, 2007	
				ACH	Air changes per hour	2	hr^{-1}	VDEQ, 2007	
				V	Volume of trench	5.42	m^3	VDEQ, 2007	
				10-3	Conversion factor	1.00E-03	L/cm^3	VDEQ, 2007	
				104	Conversion factor	1.00E+04	cm^2/m^2	VDEQ, 2007	
				3600	Conversion factor	3600	s/hr	VDEQ, 2007	
				kiL	Liquid-phase mass transfer coefficient of i	Chemical-specific	cm/s		
				R	Ideal gas constant	8.20E-05	$atm\text{-}m^3/mole\text{-}K$	VDEQ, 2007	$K_i = \left(\frac{1}{k_{iL}} + \frac{R \times T}{H_i \times k_{iG}}\right)$
				T	Average system absolute temperature	298	K	VDEQ, 2007	
				Hi	Henry's Law constant of i	Chemical-specific	$atm\text{-}m^3/mole$	VDEQ, 2007	where
				KiG	Gas-phase mass transfer coefficient of i	Chemical-specific	cm/s	VDEQ, 2007	
				MWO2	Molecular weight of O2	32	g/mol	VDEQ, 2007	$k_{iL} = \left(\frac{MW_{O_2}}{MW_i}\right)^{0.5} \times \left(\frac{T}{298}\right) \times k_{L,O_2}$
				MWi	Molecular weight of contaminant i	Chemical-specific	g/mol	VDEQ, 2007	
				kL,O2	Liquid-film mass transfer coefficient, O2	0.002	cm/s	VDEQ, 2007	and
				MWH2O	Molecular weight of water	18	g/mol	VDEQ, 2007	$k_{iG} = \left(\frac{MW_{H_2O}}{MW_i}\right)^{0.335} \times \left(\frac{T}{298}\right)^{1.005} \times k_{G,H_2O}$
				kg(H2O)	Gas-phase mass transfer coefficient of water	0.833	cm/s	VDEQ, 2007	

References:

EPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

VDEQ, 2007 - Spreadsheet from Virginia Department of Environmental Quality - Table 3.22, Values for Dermal Absorption Models and Voluntary Remediation Program Risk Assessment Guidance (http://www.deq.virginia.gov/vrprisk/raguide.html).

$atm\text{-}m^3/mol$ = atmospheres-cubic meters per mole
cm/s = centimeters per second
cm^2/m^2 = square centimeters per square meter
cm^2/s = square centimeters per second
g/mol = grams per mole
L/cm^3 = liters per cubic centimeter
L/m^3 = liters per cubic meter
mg/m^3 = milligrams per cubic meter
s/hr = seconds per hour
µg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter

Table 5-25
Values Used for Daily Intake Calculations
Incidental Ingestion of Surface Water by Maintenance Workers and Visitors
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timeframe:	Current/Future
Receptor:	Maintenance Worker, Adult
	Visitor, Youth
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Maintenance worker	Adult	Surface Water in East Toll Gate Creek	EPC	Exposure point concentration	Chemical-specific	mg/L		Chronic Daily Intake (CDI) (mg/kg-day) = EPC x IR-SD x ET x EF X ED X 1/BW x 1/AT
				IR-SW	Ingestion rate of surface water	0.05	L/hr	EPA, 1989	
				ET	Exposure time	1	hr/day	Professional Judgement	
				EF	Exposure frequency	12	days/year	Professional Judgement	
				ED	Exposure duration	25	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	9,125	days	EPA, 2002	
	Visitor	Youth	Surface Water in East Toll Gate Creek	EPC	Exposure point concentration	Chemical-specific	mg/L		Chronic Daily Intake (CDI) (mg/kg-day) = EPC x IR-SD x ET x EF X ED X 1/BW x 1/AT
				IR-SW	Ingestion rate of surface water	0.05	L/hr	EPA, 1989	
				ET	Exposure time	2	hr/day	Professional Judgement	
				EF	Exposure frequency	24	days/year	Professional Judgement	
				ED	Exposure duration	6	years	Assume youths ages 12 to 17 years	
				BW	Body weight	60	kg	50th percentile body weight for 12-17 year olds (EPA, 1997).	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 2002	

References:

EPA, 1989 - Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A)
EPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.
EPA, 1997 - Exposure Factors Handbook

hr/day = hours per day
kg = kilograms
L/hr = liters per hour
mg/L = milligrams per liter

Table 5-26
Values Used for Daily Intake Calculations
Dermal Contact with Surface Water by Maintenance Workers and Visitors
Site 11 RI, Buckley Air Force Base, Colorado

Scenario Timeframe:	Future
Receptor:	Maintenance Worker, Adult Visitor, Youth
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Maintenance Worker	Adult	Surface Water in East Toll Gate Creek	SA	Skin surface area available for contact	6,900	cm^2	Assume feet, lower legs, hands, and head - EPA, 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA_{EVENT} x EV X SA X EF X ED X1/BW x 1/AT
				DA_{EVENT}	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				EV	Event frequency	1	event/day	Professional Judgement	
				EF	Exposure frequency	12	days/year	Professional Judgement	
				ED	Exposure duration	25	years	EPA, 2002	
				BW	Body weight	70	kg	EPA, 2002	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	9,125	days	EPA, 2002	
Dermal	Visitor	Youth	Surface Water in East Toll Gate Creek	SA	Skin surface area available for contact	3,300	cm^2	Assume feet, lower legs, hands, and head - EPA, 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA_{EVENT} x EV X SA X EF X ED X1/BW x 1/AT
				DA_{EVENT}	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				EV	Event frequency	1	event/day	Professional Judgement	
				EF	Exposure frequency	24	days/year	Professional Judgement	
				ED	Exposure duration	6	years	Assume youths ages 12 to 17 years	
				BW	Body weight	60	kg	50th percentile body weight for 12-17 year olds (EPA, 1997).	
				AT-C	Averaging time (cancer)	25,550	days	EPA, 2002	
				AT-NC	Averaging Time (Non-Cancer)	2,190	days	EPA, 2002	
Dermal	Maintenance Worker and Visitor	Adult and Youth	Surface Water in East Toll Gate Creek	FA	Fraction absorbed water	Chemical-specific	unitless	App. B, EPA 2004	
				K_p	Dermal permeability coefficient	Chemical-specific	cm/hour		
				C_w	Chemical concentration in water	Chemical-specific	µg/L		If $t_{event} \le t^*$, then: $DA_{event} = 2\,FA \times K_p \times C_w \sqrt{\frac{6\,\tau_{event} \times t_{event}}{\pi}}$
				CF1	Conversion factor	1.00E-03	mg/µg	--	
				CF2	Conversion factor	1.00E-03	L/cm^3	--	If $t_{event} > t^*$, then:
				B	Ratio of Permeability Coefficient	Chemical-specific	unitless	Eq. A.1, EPA 2004	$DA_{event} = FA \times K_p \times C_w \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
				t*	Time to reach steady state	Chemical-specific	hour	Eq. A.5 to A.8, EPA 2004	
				τ_{event}	Lag time per event	Chemical-specific	hr/event	App. B, EPA 2004	
				t_{event}	Event duration	2.00	hr/event	Professional Judgement	

References: EPA, 1997 - Exposure Factors Handbook
EPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.
EPA, 2004 - RAGS, Part E - Supplemental Guidance for Dermal Risk Assessment.

cm^2 = square centimeters
kg = kilograms
L/cm^3 = liters per cubic centimeter
mg/cm^2-event = milligrams per square centimeters-event
mg/µg = milligrams per micrograms
µg/L = micrograms per liter

Table 5-27
Toxicity Values for COPCs
Oral Slope Factors
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Oral Slope Factor (kg-day/mg)	Source[1]	Species	Endpoints
Bromodichloromethane	6.2E-02	IRIS	Mouse	Kidney tubular cell adenoma and adenocarcinoma
Carbon tetrachloride	7.0E-02	IRIS	Mouse	Hepatocellular adenoma or carcinoma
Chloroform	3.1E-02	CalEPA/EPA RSL	--	--
1,2-Dichloroethane	9.1E-02	IRIS	Rat	Hamangiosarcoma
cis-1,2-Dichloroethylene	--	--	--	--
Naphthalene	--	--	--	--
Tetrachloroethene	5.4E-01	CalEPA/EPA RSL		
Trichloroethylene	5.9E-03	CalEPA/EPA RSL	--	--

Notes:
[1] Toxicity values obtained from EPA (2010) Regional Screening Level table
"--" = information not
available
CalEPA = California Environmental Protection Agency
COPC = Chemical of Potential Concern
EPA RSL = U.S. Environmental Protection Agency Regional Screening Leve
IRIS = Integrated Risk Information System
kg-day/mg = kilogram-day per milligram

U.S. Environmental Protection Agency (EPA). 2010. Regional Screening Level Tables. May 17
On-line at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Table 5-28
Toxicity Values for COPCs
Inhalation Slope Factors and Unit Risk Values
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Unit Risk (m^3/ug)	Inhalation Slope Factor (kg-day/mg)	Source[1]	Species	Endpoints
Bromodichloromethane	3.7E-05	1.3E-01	CalEPA	--	--
Carbon tetrachloride	6.0E-06	2.1E-02	IRIS	Mouse	Pheochromocytoma
Chloroform	2.3E-05	8.1E-02	IRIS	Mouse	Hepatocellular carcinoma
1,2-Dichloroethane	2.6E-05	9.1E-02	IRIS	Rats	Hemagiosarcoma
cis-1,2-Dichloroethylene	--	--	--	--	--
Naphthalene	3.4E-05	1.2E-01	CalEPA/EPA RSL	--	--
Tetrachloroethene	5.9E-06	2.1E-02	CalEPA/EPA RSL	--	--
Trichloroethylene	2.0E-06	7.0E-03	CalEPA/EPA RSL	--	--

Notes:
[1] Toxicity values obtained from EPA (2010) Regional Screening Level tables
CalEPA = California Environmental Protection Agency
COPC = Chemical of Potential Concern
EPA RSL = U.S. Environmental Protection Agency Regional Screening Level
IRIS = Integrated Risk Information System
kg-day/mg = kilogram-day per milligram
$m^3/\mu g$ = cubic meters per microgram

U.S. Environmental Protection Agency (EPA). 2010. Regional Screening Level Tables. May 17.
On-line at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Table 5-29
Cancer Classification for COPCs
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Cancer Classification[1]	Source
Bromodichloromethane	B2	IRIS
Carbon tetrachloride	B2	IRIS
Chloroform	B2	IRIS
1,2-Dichloroethane	B2	IRIS
cis-1,2-Dichloroethylene	D	IRIS
Naphthalene	C	IRIS
Tetrachloroethene	--	(2)
Trichloroethylene	--	(2)

Notes:
[1] Cancer Classifications:
A-Known Human Carcinogen
B2-Probable Human Carcinogen
C-Possible Human Carcinogen
D- Not classifiable as to human carcinogenicity
[2] Not classified by EPA. International Agency for Research on Cancer (IARC) classification: 2A - probably carcinogenic to humans
Agents Classified by the *IARC Monographs* , Volumes 1–100 (May 26, 2010)
http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf

COPC = Chemical of Potential Concern
IRIS = Integrated Risk Information System

-- = Cancer classification not available

Table 5-30
Toxicity Values for COPCs
Oral Reference Doses
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Chronic Oral RfD (mg/kg-day)	Source	Species	Endpoints	Subchronic Oral RfD (mg/kg-day)[1]	Source	Species	Endpoints
Bromodichloromethane	2.0E-02	IRIS	Mouse	Renal cytomegaly	2.0E-02	HEAST	Mouse	Renal cytomegaly
Carbon tetrachloride	4.0E-03	IRIS	Rat	Liver lesions	4.0E-03	IRIS	Rat	Liver lesions
Chloroform	1.0E-02	IRIS	Dog	Fatty cyst formation in the liver and elevated SGPT	1.0E-02	HEAST	Dog	Fatty cyst formation in the liver and elevated SGPT
1,2-Dichloroethane	2.0E-02	PPRTV/EPA RSL	--	--	2.0E-02	PPRTV/EPA RSL	--	--
cis-1,2-Dichloroethylene	1.0E-02	PPRTV/EPA RSL	--	--	1.0E-01	HEAST	Rat	Blood effects
Naphthalene	2.0E-02	IRIS	Rat	Decreased mean terminal body weight in males	2.0E-02	IRIS	Rat	Decreased mean terminal body weight in males
Tetrachloroethene	1.0E-02	IRIS	Mouse	Hepatotoxicity	1.0E-01	HEAST	Mouse	Hepatotoxicity
Trichloroethylene	--	--	--	--	--	--	--	--

Notes:
[1] The chronic oral RfD will be used for scenarios that are subchronic in duration if no subchronic toxicity values are available.
"--" = information not available
COPC = Chemical of Potential Concern
EPA RSL = U.S. Environmental Protection Agency Regional Screening Level
HEAST = Health Effects Assessment Summary Tables
IRIS = Integrated Risk Information System
mg/kg-day = milligrams per kilogram -day
PPRTV - Provisional Peer Reviewed Toxicity Value
RfD = reference dose

U.S. Environmental Protection Agency (EPA). 2010. Regional Screening Level Tables. May 17.
On-line at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Table 5-31
Toxicity Values for COPCs
Inhalation Reference Doses and Reference Concentrations
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Chronic RfC (mg/m^3)	Chronic Inhalation RfD (mg/kg-day)[1]	Source	Species	Endpoints	Subchronic Inhalation RfC (mg/m^3)	Subchronic Inhalation RfD[2] (mg/kg-day)	Source	Species	Endpoints
Bromodichloromethane	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	1.0E-01	2.9E-02	IRIS	Rat	Hepatic effects	(3)	(4)	--	--	--
Chloroform	9.8E-02	2.8E-02	ATSDR MRL/EPA RSL	Human	Hepatic effects	(3)	(4)	--	--	--
1,2-Dichloroethane	2.4E+00	6.9E-01	ATSDR MRL/EPA RSL	Rat	Hepatic effects	(3)	(4)	--	--	--
cis-1,2-Dichloroethylene	--	--	--	--	--	--	--	--	--	--
Naphthalene	3.0E-03	8.6E-04	IRIS	Mouse	Nasal effects: hyperplasia and metaplasia in respiratory and olfactory epithelium, respectively	(3)	(4)	--	--	--
Tetrachloroethene	2.7E-01	7.7E-02	ATSDR MRL/EPA RSL	Human	Neurological	(3)	(4)	--	--	--
Trichloroethylene	--	--	--	--	--	--	--	--	--	--

Notes:
[1]Chronic inhalation RfD calculated from chronic RfC assuming an inhalation rate of 20 m^3/day and body weight of 70 kg.
[2]Subchronic inhalation RfD calculated from subchronic RfC assuming an inhalation rate of 20 m^3/day and body weight of 70 kg.
[3] The chronic inhalation RfC will be used for scenarios that are subchronic in duration when no toxicity data are available.
[4] The chronic inhalation RfD will be used for scenarios that are subchronic in duration when no toxicity data are available.
"--" - information not available
ATSDR MRL - Agency for Toxic Substances and Disease Registry Minimal Risk Level
COPC = Chemical of Potential Concern
EPA RSL = U.S. Environmental Protection Agency Regional Screening Level
IRIS = Integrated Risk Information System
kg = kilograms
mg/kg-day = milligrams per kilogram -day
mg/m^3 = milligrams per cubic meter
RfC = reference concentration
RfD = reference dose

U.S. Environmental Protection Agency (EPA). 2010. Regional Screening Level Tables. May 17.
On-line at: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

Table 5-32
Summary of Risks to Commercial Workers
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities			
	Groundwater			
COPC	**Ingestion of Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	3.12E-07	5.85E-09	3.18E-07	0.077%
Carbon tetrachloride	1.38E-07	9.80E-09	1.48E-07	0.036%
Chloroform	2.49E-07	2.46E-08	2.74E-07	0.066%
Naphthalene	-	4.60E-08	4.60E-08	0.011%
Tetrachloroethene	**4.10E-04**	**1.27E-06**	**4.11E-04**	99.8%
Trichloroethene	1.72E-07	5.77E-10	1.72E-07	0.042%
Total:	**4.11E-04**	**1.36E-06**	**4.12E-04**	100.0%

	Hazard Index (HI)			
	Groundwater			
COPC	**Ingestion of Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	7.05E-04	-	7.05E-04	0.32%
Carbon tetrachloride	1.38E-03	4.57E-05	1.43E-03	0.65%
Chloroform	2.25E-03	3.05E-05	2.28E-03	1.03%
Naphthalene	4.09E-04	1.26E-03	1.67E-03	0.757%
Tetrachloroethene	2.13E-01	2.23E-03	2.15E-01	97.2%
Trichloroethene	-	-	-	0.00%
Total:	2.17E-01	3.57E-03	2.21E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-33
Summary of Risks to Construction Workers
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities		
	Groundwater		
COPC	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Contribution**
Bromodichloromethane	5.05E-10	5.05E-10	0.28%
Carbon tetrachloride	9.41E-11	9.41E-11	0.051%
Chloroform	2.12E-09	2.12E-09	1.2%
Naphthalene	8.54E-11	8.54E-11	0.047%
Tetrachloroethene	1.79E-07	1.79E-07	97.7%
Trichloroethene	1.42E-09	1.42E-09	0.78%
Total:	1.83E-07	1.83E-07	100.0%

	Hazard Index (HI)		
	Groundwater		
COPC	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Contribution**
Bromodichloromethane	-	-	0.00%
Carbon tetrachloride	2.20E-05	2.20E-05	0.14%
Chloroform	1.32E-04	1.32E-04	0.83%
Naphthalene	1.17E-04	1.17E-04	0.73%
Tetrachloroethene	1.57E-02	1.57E-02	98.3%
Trichloroethene	-	-	0.00%
Total:	1.60E-02	1.60E-02	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-34
Summary of Risks to Adult Residents
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	4.20E-07	3.44E-08	2.36E-08	4.78E-07	0.067%
Carbon tetrachloride	1.86E-07	5.00E-08	3.95E-08	2.76E-07	0.039%
Chloroform	3.35E-07	3.06E-08	9.91E-08	4.65E-07	0.065%
Naphthalene	-	-	1.85E-07	1.85E-07	0.026%
Tetrachloroethene	**5.51E-04**	**1.54E-04**	**5.12E-06**	**7.10E-04**	99.8%
Trichloroethene	2.31E-07	4.00E-08	2.33E-09	2.73E-07	0.038%
Total:	**5.52E-04**	**1.55E-04**	**5.47E-06**	**7.12E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	9.88E-04	8.10E-05	-	1.07E-03	0.26%
Carbon tetrachloride	1.94E-03	5.20E-04	1.92E-04	2.65E-03	0.66%
Chloroform	3.15E-03	2.88E-04	1.28E-04	3.57E-03	0.88%
Naphthalene	5.73E-04	3.83E-04	5.30E-03	6.25E-03	1.55%
Tetrachloroethene	2.98E-01	8.34E-02	9.37E-03	3.90E-01	96.6%
Trichloroethene	-	-	-	-	0.00%
Total:	3.04E-01	8.47E-02	1.50E-02	4.04E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-35
Summary of Risks to Child Residents
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	2.45E-07	1.93E-08	5.89E-09	2.70E-07	0.067%
Carbon tetrachloride	1.09E-07	2.80E-08	9.88E-09	1.46E-07	0.0093%
Chloroform	1.95E-07	1.71E-08	2.48E-08	2.37E-07	0.058%
Naphthalene	-	-	4.63E-08	4.63E-08	0.011%
Tetrachloroethene	**3.21E-04**	**8.24E-05**	**1.28E-06**	**4.05E-04**	99.8%
Trichloroethene	1.34E-07	2.24E-08	5.82E-10	1.57E-07	0.039%
Total:	**3.22E-04**	**8.24E-05**	**1.37E-06**	**4.06E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethan	2.30E-03	1.81E-04	-	2.49E-03	0.27%
Carbon tetrachloride	4.52E-03	1.17E-03	1.92E-04	5.88E-03	0.6%
Chloroform	7.35E-03	6.45E-04	1.28E-04	8.12E-03	0.90%
Naphthalene	1.34E-03	8.58E-04	5.30E-03	7.49E-03	0.83%
Tetrachloroethene	6.94E-01	1.78E-01	9.37E-03	8.82E-01	97.4%
Trichloroethene	-	-	-	-	0.00%
Total:	7.10E-01	1.81E-01	1.50E-02	9.06E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-36
Summary of Lifetime Risks to Residents (Adult + Child)
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	6.65E-07	5.37E-08	2.95E-08	7.48E-07	0.067%
Carbon tetrachloride	1.86E-07	7.79E-08	4.94E-08	3.13E-07	0.028%
Chloroform	5.30E-07	4.77E-08	1.24E-07	7.02E-07	0.063%
Naphthalene	-	-	2.32E-07	2.32E-07	0.021%
Tetrachloroethene	**8.72E-04**	**2.37E-04**	**6.40E-06**	**1.12E-03**	99.8%
Trichloroethene	3.65E-07	6.25E-08	2.91E-09	4.30E-07	0.039%
Total:	**8.74E-04**	**2.37E-04**	**6.84E-06**	**1.12E-03**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Bromodichloromethane	3.29E-03	2.62E-04	-	3.55E-03	0.27%
Carbon tetrachloride	6.46E-03	1.69E-03	3.84E-04	8.53E-03	0.65%
Chloroform	1.05E-02	9.33E-04	2.56E-04	1.17E-02	0.89%
Naphthalene	1.91E-03	1.24E-03	1.06E-02	1.37E-02	1.05%
Tetrachloroethene	9.92E-01	2.61E-01	1.87E-02	**1.27E+00**	97.1%
Trichloroethene	-	-	-	-	0.00%
Total:	**1.01E+00**	2.65E-01	3.00E-02	**1.31E+00**	100.0%

Notes:
Values in **bold** indicate a cancer risk >$1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-37
Summary of Risks to Maintenance Workers
Off-Base Surface Water
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities			
	Groundwater			
COPC	**Ingestion of Surface Water**	**Dermal Absorption from Surface Water**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	2.13E-10	6.91E-09	7.13E-09	100.0%
Total:	2.13E-10	6.91E-09	7.13E-09	100.0%

	Hazard Index (HI)			
	Groundwater			
COPC	**Ingestion of Surface Water**	**Dermal Absorption from Surface Water**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	1.10E-07	3.83E-06	3.94E-06	100.0%
Total:	1.10E-07	3.83E-06	3.94E-06	100.0%

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

COPC = Chemical of Potential Concern

Table 5-38
Summary of Risks to Construction Workers
Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	7.97E-09	6.47E-08	6.57E-07	7.30E-07	93.32%
Trichloroethene	1.74E-11	2.27E-09	4.99E-08	5.22E-08	6.68%
Total:	7.99E-09	6.70E-08	7.07E-07	7.82E-07	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	2.07E-04	1.68E-03	5.77E-02	5.96E-02	100.0%
Trichloroethene	-	-	-	-	0.00%
Total:	2.07E-04	1.68E-03	5.77E-02	5.96E-02	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

"-" - There is no toxicity data for this COPC, so no risk can be calculated.

Table 5-39
Summary of Risks to Adult Residents
Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	**1.12E-04**	**3.13E-05**	**6.35E-06**	**1.49E-04**	99.05%
Trichloroethene	2.44E-07	9.03E-07	2.89E-07	1.44E-06	0.95%
Total:	**1.12E-04**	**3.22E-05**	**6.64E-06**	**1.51E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	6.03E-02	1.69E-02	1.16E-02	8.88E-02	100.00%
Trichloroethene	-	-	-	-	0.00%
Total:	6.03E-02	1.69E-02	1.16E-02	8.88E-02	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-40
Summary of Risks to Child Residents
Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	Ingestion of Groundwater	Dermal Absorption from Groundwater	Inhalation of Indoor Vapors from Groundwater	Summation	Percent Contribution to Total
Tetrachloroethene	**6.51E-05**	**1.67E-05**	**1.59E-06**	**8.34E-05**	99.14%
Trichloroethene	1.42E-07	5.06E-07	7.21E-08	7.20E-07	0.86%
Total:	**6.52E-05**	**1.72E-05**	**1.66E-06**	**8.41E-05**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	Ingestion of Groundwater	Dermal Absorption from Groundwater	Inhalation of Indoor Vapors from Groundwater	Summation	Percent Contribution to Total
Tetrachloroethene	1.41E-01	3.60E-06	1.16E-02	1.88E-01	100.00%
Trichloroethene	-	-	-	-	0.00%
Total:	1.41E-01	3.60E-06	1.16E-02	1.88E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-41
Summary of Lifetime Risks to Residents (Adult + Child)
Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	**1.77E-04**	**4.80E-05**	**7.94E-06**	**2.33E-04**	99.08%
Trichloroethene	3.86E-07	**1.41E-06**	3.61E-07	**2.15E-06**	0.92%
Total:	**1.77E-04**	**4.94E-05**	**8.30E-06**	**2.35E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Percent Contribution to Total**
Tetrachloroethene	2.01E-01	5.29E-02	2.33E-02	2.77E-01	100.00%
Trichloroethene	-	-	-	-	0.00%
Total:	2.01E-01	5.29E-02	2.33E-02	2.77E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-42
Summary of Risks to Visitors
Off-Base Surface Water
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities			
	Surface Water			
COPC	**Ingestion of Surface Water**	**Dermal Contact with Surface Water**	**Total Cancer Risk**	**Percent Contribution to Total**
Tetrachloroethene	2.38E-10	5.83E-09	6.07E-09	100.0%
Total Cancer Risk:	2.38E-10	5.83E-09	6.07E-09	100.0%

	Hazard Index (HI)			
	Surface Water			
COPC	**Ingestion of Surface Water**	**Dermal Contact with Surface Water**	**Total HI**	**Percent Contribution to Total**
Tetrachloroethene	5.15E-07	1.26E-05	1.31E-05	100.0%
Total Hazard Index:	5.15E-07	1.26E-05	1.31E-05	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-43
Summary of Risks to Commercial Workers
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities			
	Groundwater			
COPC	**Ingestion of Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	**6.85E-05**	6.55E-07	**6.91E-05**	65.1%
Chloroform	**2.03E-05**	5.71E-07	**2.09E-05**	19.7%
1,2-Dichloroethane	**3.83E-06**	-	**3.83E-06**	3.6%
Naphthalene	-	6.83E-10	6.83E-10	0.00064%
Trichloroethene	**2.71E-06**	**9.57E-06**	**1.23E-05**	11.6%
Total:	**9.54E-05**	**1.08E-05**	**1.06E-04**	100.0%

	Hazard Index (HI)			
	Groundwater			
COPC	**Ingestion of Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	6.85E-01	3.05E-03	6.88E-01	78.3%
Chloroform	1.84E-01	7.10E-04	1.84E-01	21.0%
1,2-Dichloroethane	5.89E-03	1.18E-06	5.89E-03	0.67%
Naphthalene	2.35E-04	1.88E-05	2.54E-04	0.029%
Trichloroethene	-	-	-	0.0%
Total:	8.75E-01	3.78E-03	8.78E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-44
Summary of Risks to Construction Workers
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities		
	Groundwater		
COPC	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Contribution**
Carbon tetrachloride	4.19E-07	4.19E-07	68.2%
Chloroform	1.73E-07	1.73E-07	28.2%
1,2-Dichloroethane	-	-	0.00%
Naphthalene	4.89E-11	4.89E-11	0.0080%
Trichloroethene	2.25E-08	2.25E-08	3.7%
Total:	6.15E-07	6.15E-07	100.0%

	Hazard Index (HI)		
	Groundwater		
COPC	**Inhalation of Outdoor Vapor in Trench**	**Summation**	**Contribution**
Carbon tetrachloride	9.78E-02	9.78E-02	90.0%
Chloroform	1.08E-02	1.08E-02	9.9%
1,2-Dichloroethane	7.52E-06	7.52E-06	0.0%
Naphthalene	6.71E-05	6.71E-05	0.06182%
Trichloroethene	-	-	0.00%
Total:	1.09E-01	1.09E-01	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-45
Summary of Risks to Adult Residents
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	**9.21E-05**	**1.66E-05**	**2.64E-06**	**1.11E-04**	57.1%
Chloroform	**2.73E-05**	1.60E-07	**2.30E-06**	**2.98E-05**	15.3%
1,2-Dichloroethane	**5.15E-06**	**5.89E-06**	**-**	**1.10E-05**	5.7%
Naphthalene	-	-	2.76E-09	2.76E-09	0.0014%
Trichloroethene	**3.65E-06**	6.33E-07	**3.86E-05**	**4.29E-05**	22.0%
Total:	**1.28E-04**	**2.32E-05**	**4.35E-05**	**1.95E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	9.59E-01	1.72E-01	1.28E-02	**1.14E+00**	80.4%
Chloroform	2.57E-01	1.51E-03	2.98E-03	2.61E-01	18.4%
1,2-Dichloroethane	8.25E-03	9.43E-03	4.94E-06	1.77E-02	1.2%
Naphthalene	3.29E-04	2.20E-04	7.88E-05	6.27E-04	0.044%
Trichloroethene	-	-	-	-	0.00%
Total:	**1.22E+00**	1.84E-01	1.59E-02	**1.42E+00**	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-46
Summary of Risks to Child Residents
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	**5.37E-05**	**9.27E-06**	6.60E-07	**6.36E-05**	64.4%
Chloroform	**1.59E-05**	8.97E-08	5.76E-07	**1.66E-05**	16.8%
1,2-Dichloroethane	**3.00E-06**	**3.41E-06**	-	**6.41E-06**	6.5%
Naphthalene	-	-	6.89E-10	6.89E-10	0.00070%
Trichloroethene	**2.13E-06**	3.55E-07	**9.65E-06**	**1.21E-05**	12.3%
Total:	**7.48E-05**	**1.31E-05**	**1.09E-05**	**9.88E-05**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	**Ingestion of Groundwater**	**Dermal Absorption from Groundwater**	**Inhalation of Indoor Vapors from Groundwater**	**Summation**	**Contribution**
Carbon tetrachloride	**2.24E+00**	3.86E-01	1.28E-02	**2.64E+00**	80.3%
Chloroform	6.00E-01	3.38E-03	2.98E-03	6.06E-01	18.4%
1,2-Dichloroethane	1.92E-02	2.18E-02	4.94E-06	4.11E-02	1.25%
Naphthalene	7.67E-04	4.92E-04	7.88E-05	1.34E-03	0.041%
Trichloroethene	-	-	-	-	0.00%
Total:	**2.86E+00**	4.12E-01	1.59E-02	**3.29E+00**	100.0%

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-47
Summary of Lifetime Risks to Residents (Adult + Child)
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

	Cancer Risk Probabilities				
	Groundwater				
COPC	Ingestion of Groundwater	Dermal Absorption from Groundwater	Inhalation of Indoor Vapors from Groundwater	Summation	Contribution
Carbon tetrachloride	**1.46E-04**	**2.58E-05**	**3.30E-06**	**1.75E-04**	59.5%
Chloroform	**4.32E-05**	2.50E-07	**2.88E-06**	**4.64E-05**	15.8%
1,2-Dichloroethane	**8.15E-06**	**9.29E-06**	**-**	**1.74E-05**	5.9%
Naphthalene	**-**	-	3.44E-09	3.44E-09	0.0012%
Trichloroethene	**5.77E-06**	9.88E-07	**4.82E-05**	**5.50E-05**	18.7%
Total:	**2.03E-04**	**3.64E-05**	**5.44E-05**	**2.94E-04**	100.0%

	Hazard Index (HI)				
	Groundwater				
COPC	Ingestion of Groundwater	Dermal Absorption from Groundwater	Inhalation of Indoor Vapors from Groundwater	Summation	Contribution
Carbon tetrachloride	**3.20E+00**	5.59E-01	2.57E-02	**3.78E+00**	80.29%
Chloroform	8.57E-01	4.88E-03	5.96E-03	8.67E-01	18.4%
1,2-Dichloroethane	2.75E-02	3.13E-02	9.88E-06	5.88E-02	1.25%
Naphthalene	1.10E-03	7.12E-04	1.58E-04	1.97E-03	0.042%
Trichloroethene	-	-	-	0.00E+00	0.00%
Total:	**4.08E+00**	5.96E-01	3.18E-02	**4.71E+00**	100.0%

Notes:

Values in **bold** indicate a cancer risk >$1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern

Table 5-48
Summary of Potential Risks to All Receptors
On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Exposure Route	Cancer Risk	Percent of Total Risk	Hazard Index	Percent of Total Risk
Commercial Worker				
Groundwater ingestion	**4.11E-04**	99.7%	2.17E-01	98.4%
Indoor vapor inhalation	**1.36E-06**	0.33%	3.57E-03	1.62%
Total	**4.12E-04**		2.21E-01	
Construction Workers				
Vapor inhalation in trench	1.83E-07	100.0%	1.60E-02	100.0%
Total	1.83E-07		1.60E-02	
Residential Adults				
Groundwater ingestion	**5.52E-04**	77.5%	3.04E-01	75.3%
Groundwater dermal contact	**1.55E-04**	21.7%	8.47E-02	21.0%
Indoor vapor inhalation	**5.47E-06**	0.77%	1.50E-02	3.71%
Total	**7.12E-04**		4.04E-01	
Residential Children				
Groundwater ingestion	**3.22E-04**	79.3%	7.10E-01	78.4%
Groundwater dermal contact	**8.24E-05**	20.3%	1.81E-01	20.0%
Indoor vapor inhalation	**1.37E-06**	0.3%	1.50E-02	1.7%
Total	**4.06E-04**		9.06E-01	
Residential Adults +Children				
Groundwater ingestion	**8.74E-04**	78.2%	**1.01E+00**	77.4%
Groundwater dermal contact	**2.37E-04**	21.21%	2.65E-01	20.3%
Indoor vapor inhalation	**6.84E-06**	0.6%	3.00E-02	2.29%
Total	**1.12E-03**		**1.31E+00**	

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

Table 5-49
Summary of Potential Risks to All Receptors
Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

Exposure Route	Cancer Risk	Percent of Total Risk	Hazard Index	Percent of Total Risk
Maintenance Worker				
Surface water ingestion	2.13E-10	3.0%	1.10E-11	2.8%
Surface water dermal contact	6.91E-09	97.01%	3.83E-10	97.2%
Total	7.13E-09		3.94E-10	
Construction Workers				
Groundwater ingestion	7.99E-09	1.02%	2.07E-04	0.35%
Groundwater dermal contact	6.70E-08	8.57%	1.68E-03	2.81%
Vapor inhalation in trench	7.07E-07	90.4%	5.77E-02	96.8%
Total	7.82E-07		5.96E-02	
Residential Adults				
Groundwater ingestion	**1.12E-04**	74.2%	6.03E-02	67.9%
Groundwater dermal contact	**3.22E-05**	21.4%	1.69E-02	13.1%
Indoor vapor inhalation	**6.64E-06**	4.41%	1.16E-02	19.0%
Total	**1.51E-04**		8.88E-02	
Residential Children				
Groundwater ingestion	**6.52E-05**	77.6%	1.41E-01	74.7%
Groundwater dermal contact	**1.72E-05**	20.4%	3.60E-02	19.1%
Indoor vapor inhalation	**1.66E-06**	1.97%	1.16E-02	6.18%
Total	**8.41E-05**		1.88E-01	
Residential Adults +Children				
Groundwater ingestion	**1.77E-04**	75.4%	2.01E-01	72.5%
Groundwater dermal contact	**4.94E-05**	21.0%	5.29E-02	17.2%
Indoor vapor inhalation	**8.30E-06**	3.54%	2.33E-02	10.3%
Total	**2.35E-04**		2.77E-01	
Visitors				
Surface water ingestion	2.38E-10	3.9%	5.15E-07	3.9%
Surface water dermal contact	5.83E-09	96.1%	1.26E-05	96.1%
Total	6.07E-09		1.31E-05	

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

Table 5-50
Summary of Potential Risks to All Receptors
North Plume
Site 11 RI, Buckley Air Force Base, Colorado

Exposure Route	Cancer Risk	Percent of Total Risk	Hazard Index	Percent of Total Risk
Commercial Worker				
Groundwater ingestion	**9.54E-05**	89.8%	8.75E-01	99.6%
Indoor vapor inhalation	**1.08E-05**	10.17%	3.78E-03	0.43%
Total	**1.06E-04**		8.78E-01	
Construction Workers				
Vapor inhalation in trench	6.15E-07	100.0%	1.09E-01	100.0%
Total	6.15E-07		1.09E-01	
Residential Adults				
Groundwater ingestion	**1.28E-04**	65.7%	**1.22E+00**	86.0%
Groundwater dermal contact	**2.32E-05**	11.9%	1.84E-01	12.9%
Indoor vapor inhalation	**4.35E-05**	22.3%	1.59E-02	1.1%
Total	**1.95E-04**		**1.42E+00**	
Residential Children				
Groundwater ingestion	**7.48E-05**	75.7%	**2.86E+00**	87.0%
Groundwater dermal contact	**1.31E-05**	13.3%	4.12E-01	12.5%
Indoor vapor inhalation	**1.09E-05**	11.0%	1.59E-02	0.48%
Total	**9.88E-05**		**3.29E+00**	
Residential Adults +Children				
Groundwater ingestion	**2.03E-04**	69.1%	**4.08E+00**	86.7%
Groundwater dermal contact	**3.64E-05**	12.4%	5.96E-01	12.7%
Indoor vapor inhalation	**5.44E-05**	18.5%	3.18E-02	0.67%
Total	**2.94E-04**		**4.71E+00**	

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

APPENDIX A

LITHOLOGY LOGS FROM PREVIOUS INVESTIGATIONS

Versar INC.

Lithology Log

Sheet 1 of 1

LOCID ~~1011MW~~ CP 1011SB03			
Project Name: Building 1011 BAFD	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/5/06 1230	Date/Time Total Depth Reached: 5/5/06 1245
Drilling Company: Pitbrook Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 10 / Total Depth Logged: 10
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 4"	Water Level (bgs): First NA / Final
Type of Sampling Device: Split Spoon	Sample Hammer: Type NA	Driving Wt. 160 Drop	Checked by/Date: D. Whitesides/5.22.06

Location Description (include sketch in field logbook): UST Site

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
			7 9 8 9	Fine to Coarse sand, silt loose. 10 YR 4/3: Brown	Sm		M		80	20	PID:0.0
2			7 7 8	SAA	Sm		D		80	20	PID:0.0
4			4 3 3	Fine to med sand, silt loose 10 YR 4/3: Brown	Sm		D		80	20	PID:0.0
6			2 3 3	SAA	Sm		D		80	20	PID:0.0
8			3 5 8	Fine to med sand, silt loose 10YR 4/4: dark Yellowish Brown	Sm		M		80	20	PID:0.0
10			6 5 6	med to coarse sand, silt loose 2.5 Y 6/4: light yellowish Brown	Sm		M		80	20	PID:0.0

Versar INC.

Lithology Log

Sheet 1 of 1

LOCID: 1011SD02			
Project Name: Building 1011 BAFB	Project Number: 112000.0045	Date/Time Drilling Started: 5/5/06 1330	Date/Time Total Depth Reached: 5/5/06 1345
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 10 / Total Depth Logged: 10
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 4"	Water Level (bgs): First NA / Final
Type of Sampling Device: Split Spoon	Sample Hammer: Type NA	Driving Wt. 160 Drop	Checked by/Date: D. Whitesides/5-22-06

Location Description (include sketch in field logbook)

Hydr. Lift

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
			1. 1 4.	Coarse sand loose 2.5Y 5/4: light olive brown	SW		m		100		PID: 0.0
2			1 3 6	SAA	SW		m		100		PID: 0.0
4			4 5 5	SAA	SW		m		100		PID: 0.0
6			5 3 7	Fine sand, loose 2.5Y 4/4: olive brown	SW		m		100		
			12	coarse sand, loose 2.5Y 6/4: light yellowish brown	SW		m		100		PID: 0.0
8			11 7 7	SAA med to fine sand, loose 2.5Y 4/4: olive brown	SW		m		100		PID: 0.0
10			10 11	SAA	SW		m		100		PID: 0.0

Versar INC.

Lithology Log

Sheet 1 of 1

LOCID: 7195B01			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/4/06 1400	Date/Time Total Depth Reached: 5/4/06 1415
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 16 / Total Depth Logged: 16
Drilling Equipment: CME66	Drilling Method: Auger	Borehole Diameter: 4"	Water Level (bgs): First NA / Final
Type of Sampling Device: Split Spoon	Sample Hammer: Type NA	Driving Wt. 160 Drop	Checked by/Date: D. Whitesides/5.22.06

Location Description (include sketch in field logbook)
Sample @ 10 ft. bgs

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
			3 6 6 7	Coarse to fine sand, silt loose 10YR 4/3: Brown	Sm		D		80	20	PID: 0.6
2			16 12 14	Fine to med sand, silt low plasticity 2.5Y 6/4: light yellowish Brown	Sm		D		80	20	PID: 4.4
4			8 7 6	SAA	Sm		D		80	20	PID: 1.8
6			4 3 4 4	Fine sand, silt low plasticity 10YR 4/3: Brown	Sm		D		80	20	PID: 0.6
8			4 4 4 3	SAA	Sm		D		80	20	
				coarse sand, pebble	Sw		D	40	60		PID: 0.0
10			49 49 50	Fine sand, clay High plasticity 10YR 4/4: dark yellowish brown	Sm		D		60	40	PID: 0.0
12			50 50	SAA	Sm		D		60	40	PID: 0.1
14				Clay, fine sand High plasticity 10YR 4/2: dark grayish brown	ML		D		40	60	PID: 0.0
16											

Versar INC.

Lithology Log

Sheet 1 of 3

LOCID: 1011 mw D1			
Project Name: 1011 BAFB	Project Number: 112000.0045	Date/Time Drilling Started: 4/24/06 1000	Date/Time Total Depth Reached: 4/24/06 1530
Drilling Company: Dakota Drilling	Driller: Gabe	Hydrogeologist: C. Purcell	Total Depth Drilled: 60 / Total Depth Logged: 60
Drilling Equipment: CME 55	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs) First: 45.20 on 5/26/00 Final:
Type of Sampling Device: 5' Split Spoon		Sample Hammer Type: NA Driving Wt. Drop	Checked by/Date: D. Whitesides 5.30.06

Location Description (include sketch in field logbook)
upgrade well.
upgradient

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Coarse to fine sand, silt, pebbles 100x	Sm		D	20	60	20	PID: 0.0
2				Fine to med sand, silt loox 10YR 4/4	Sm		D		60	40	
4											
6				fine Sand silt low Plasticity; Plate 10YR 5/4 calcium veins	Sm		D		60	40	PID: 0.0
8				med sand loose, calcium staining 10YR 5/4	SW		D		100		
10				med Sand loose 2.5 Y 6/4	SW		D		100		PID: 0.1
12											
14											
16				Coarse to med. sand loose 10YR 6/4	SW		M		100		PID: 0.0
18											

WESTON INC.

Lithology Log (continued) Sheet 2 of 3

LOCID 1011 mw1 MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Claystone, weathered (Bedrock) Plate 7.5 YR 4/4	CH		D			100	PID: 0.0
22											
24				claystone High Plasticity 7.5 YR 2.5/3	CH		D			100	
26				Clay; ~~silt~~ sand fine mod. plasticity	CH		D		20	80	PID: 0.0
28				fine sand, clay High Plasicity 7.5 YR 3/4	SW		D		80	20	
30				SAA							
32				Clay High Plasicity Gley 1 7/N	CH		D			100	PID: 0.0
34											
36				Fine sand, clay lens High Plasticity 10YR 5/6	SW		M		60	40	
38											
40				SAA	SW						
42											
44											

Versar INC.

Lithology Log (continued) Sheet 3 of 3

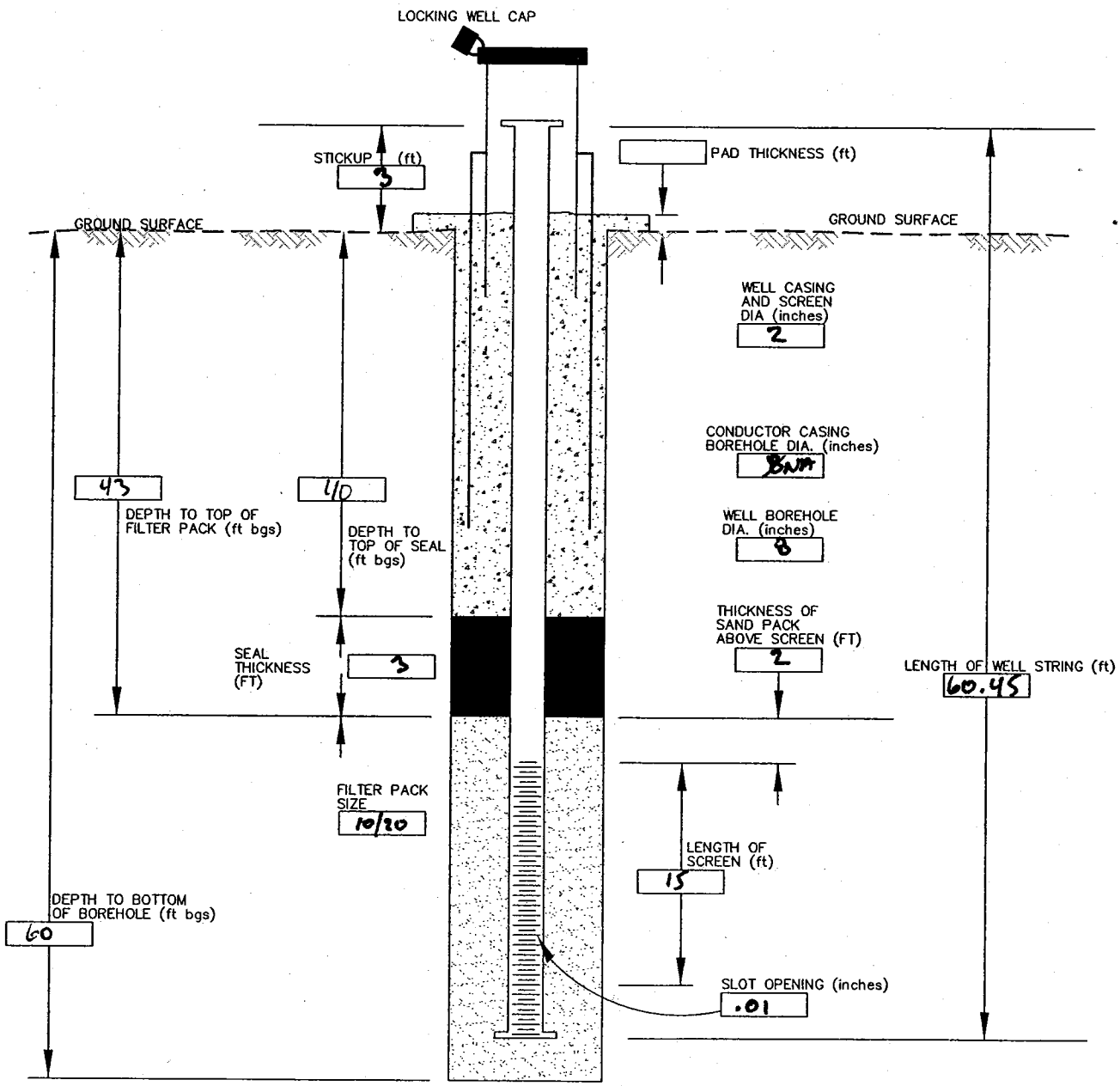
LOCID 1011 mw1 MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Denver formation	CH		D			100	
48											
50				SAA	CH						
53				coarse sand loose 7.5YR 4/6	SW		M		100		PID=0.1
54											
55				Denver formation SAA	CH		D			100	
56				Coarse sand loose	SW		W		100	100	
58											
60				Claystone	CH		D			100	

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
1011mw01	Build 1011 BAFB	112000.0045.005
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
4/24/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-30-06



COMMENTS: Approximate depths

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

Versar INC.

Lithology Log

Sheet 1 of 3

LOCID: 1011mw02			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 4/25/06 0830	Date/Time Total Depth Reached: 4/25/06 1158
Drilling Company: Dakota Drilling	Driller: Gabe	Hydrogeologist: C. Purcell	Total Depth Drilled: 60 / Total Depth Logged: 60
Drilling Equipment: CME 55	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs): First ~~NA~~ / Final 29.75 on 5/26/06
Type of Sampling Device: Split spoon	Sample Hammer: Type WP / Driving Wt. / Drop		Checked by/Date: D. Whitesides 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Coarse to Fine sand, silt loose 10YR 5/4 Calcium staining	~~Sw~~ Sm		D		80	20	PID: 0.0
2											
4											
				Fine to med. Sand, silt loose 10YR 4/4	Sm ~~Sw~~		D		80	20	PID: 1.8
6											
8											
10				Coarse to med sand loose 2.5Y 7/4	Sw		D		100		PID: 3.7
12											
14											
				Coarse sand, loose; 10YR 5/8	Sw		M		100		PID: 2.2
16											
				Fine sand, silt mod. plasticity 10YR 5/8	Sm		D		60	40	
18											

Versar INC.

Lithology Log (continued) Sheet 2 of 3

LOCID 1011mw02

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				FINE Sand, silt, plate 10YR 5/8	Sm		D		60	40	PID: 1.8
22											
24											
				SAA	Sm		D		60	40	PID: 2.2
26											
28				Fine sand clay High Plasticity 10YR 5/8	Sm		D		60	40	
30				Clay, Fine sand Plate 10YR 5/8	CL		D		40	60	PID: 1.8
32											
34											
36				med to fine sand, clay Plate 10YR 4/6	SC ~~CL~~		D		60	40	PID: 2.7
38				Fine to med sand, clay High Plastic Plasticity 10YR 4/6	SC		D		60	40	PID: 1.0
40				SAA			D				
42				Denver formation (Blue) Claystone	CH		D			100	PID: 1.0
44				SAA							

Versar INC.

Lithology Log (continued)

Sheet 3 of 3

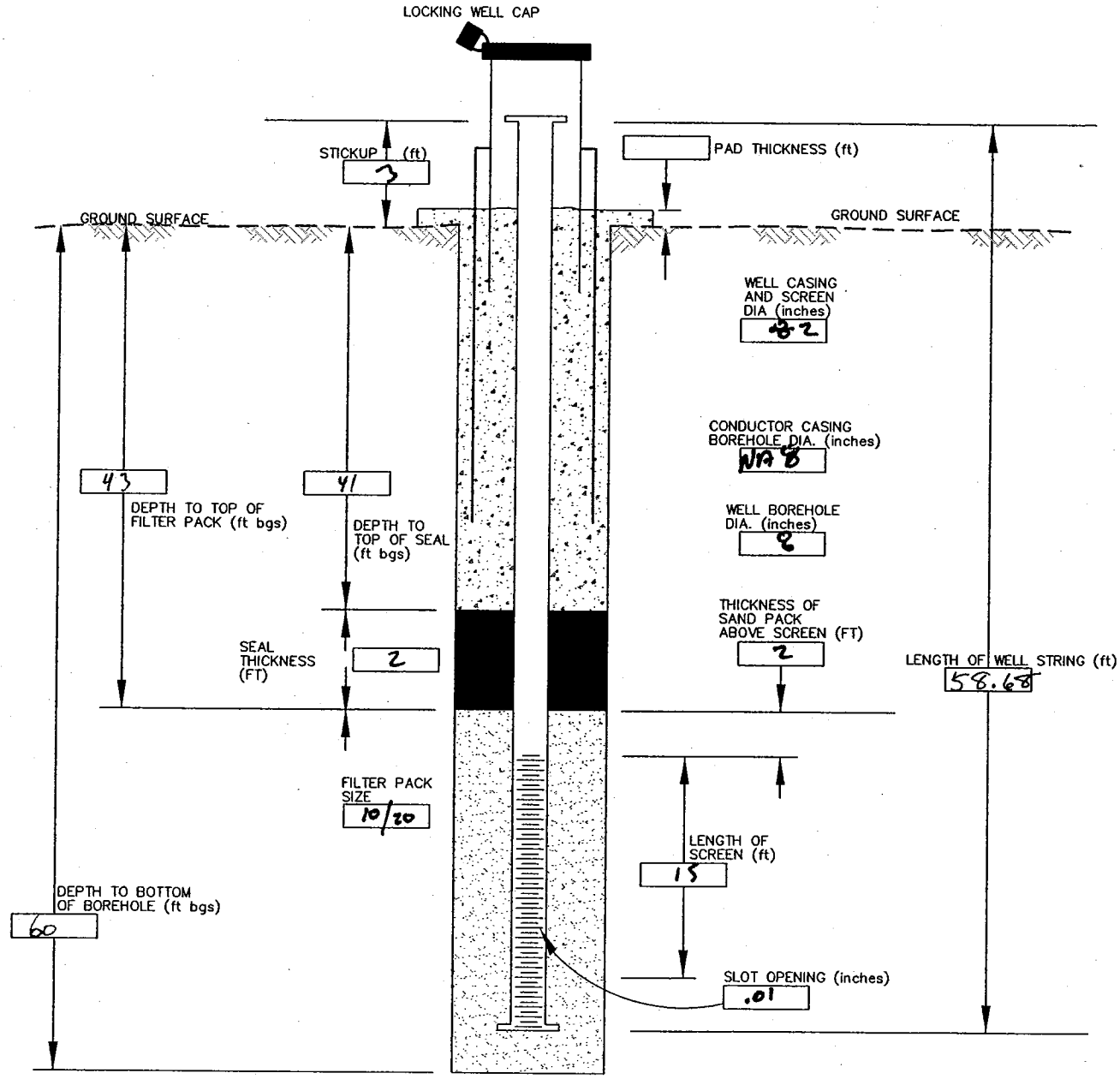
LOCID 1011MW02

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Denver formation, Claystone	CH		D			100	PID 0.0
48											
50				SAA	CH		M			100	
52											
54											
56				SAA	CH		D			100	
58											
60											
62											
64											
66											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 1011mw02	Project Name: Building 1011 BAFB	Project #: 112000.0045.005
Construction Date: 4/25/06	Drilling Method: Auger	Casing/Screen Material: PVC
Geologist: C. Purcell	Checked By: D. Whitesides	Date: 5-30-06



COMMENTS: Approximate depths

filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 3

LOCID: 1011mw03			
Project Name: Building 1011 BAFB	Project Number: 112000.0045	Date/Time Drilling Started: 4/26/06 0830	Date/Time Total Depth Reached: 4/26/06 1930
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 60 / Total Depth Logged: 60
Drilling Equipment: CME55	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs): First NA / Final 35.68 on 5/26/06
Type of Sampling Device: Split spoon	Sample Hammer: Type NA / Driving Wt. / Drop		Checked by/Date: D. Whitesides 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine sand, silt low Plasticity 10 YR 4/3:	SM		D		60	40	PID: ~~4.9~~ 2.7
2											
4											
6				Coarse to med sand loose 10YR 7/4	SW		M		100		PID: 4.9
8				Fine to med sand, silt loose 7.5YR 4/6	SM		D		60	40	
10				Fine sand, clay silt low plasticity 7.5 YR 5/6	SCM		D		60	40	PID: 7.1
12											
14											
16				SAA	SAA						
18				Clay, Fine sand moderate Plasticity 10YR 4/6	~~SC~~ CL		D		40	60	PID: 1.3

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Lithology Log (continued) Sheet 2 of 3

LOCID 1011 MW 03

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Clay, Fine sand, low plasticity 10YR 4/4	~~SC~~ CL		D		40	60	PID: 0.0
22											
24											
				SAA	~~SC~~ CL		D		40	60	PID: 0.1
26											
28											
30				med to Fine sand, clay loose, plate 10YR 5/4	SC		D		60	40	
32											
34				Clay, Fine sand moderate plasticity 10YR 4/6	CL		D		40	60	PID: 0.0
				Denver formation	CH		D			100	
36											
38											
40				Denver Fine sand, ~~silt~~ clay Plate Gley 2 2.5/10 Dk	~~CL~~ SC		D		60	40	PID: 0.0
42											
44											
				SAA	SC CL						

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Lithology Log (continued) Sheet 3 of 3

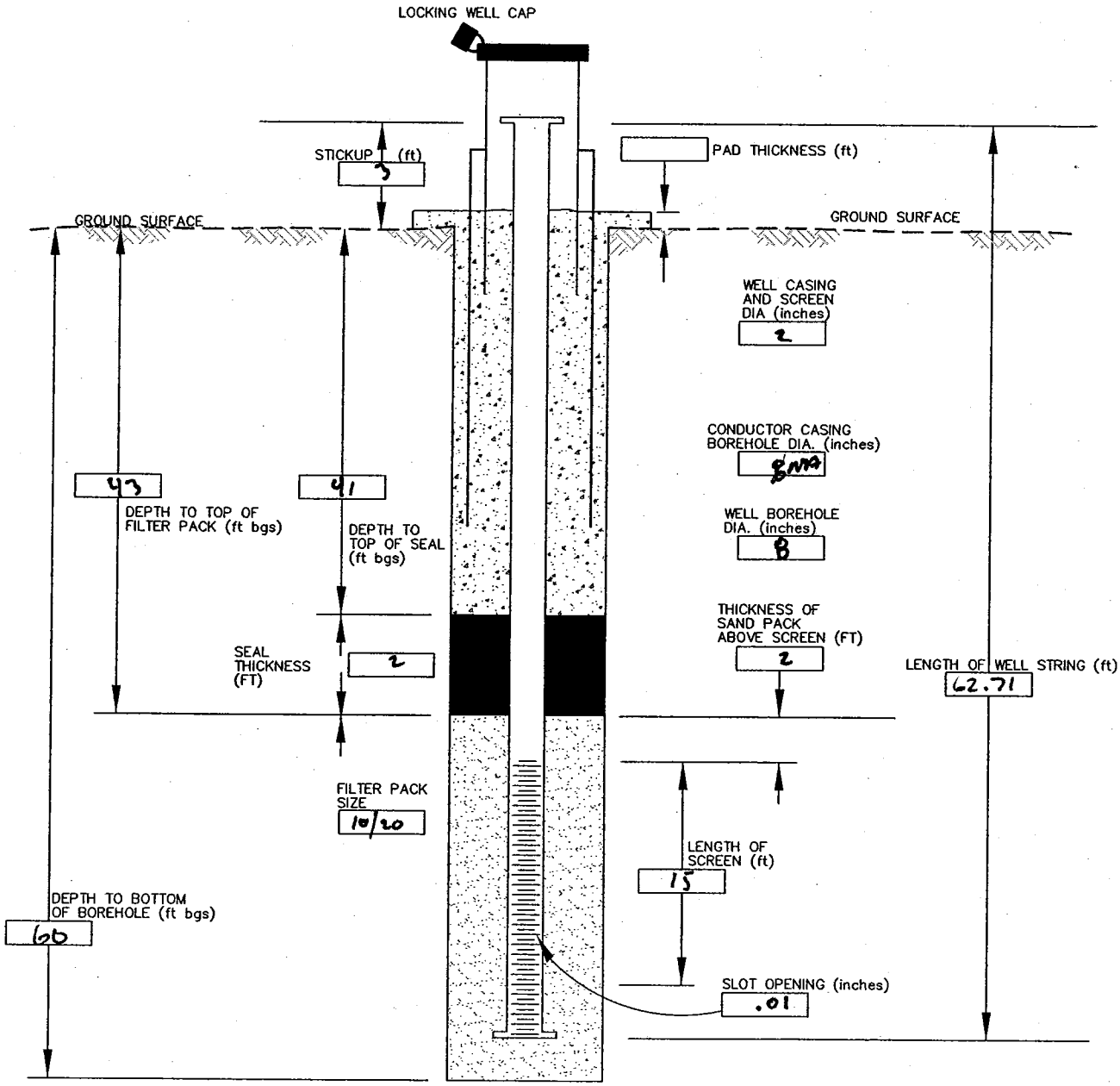
LOCID 1011 MW 03

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
48				DF : Fine sand, ~~silt~~ clay Plate Gley 2 2.5/10BG	~~GW~~ ~~SW~~ ~~CL~~ SC		D		60	40	
50				SAA	~~GW~~ ~~CH~~ ~~SW~~ ~~CL~~ ~~OH~~		D				
52											
54											
56				DF : Fine sand, ~~silt~~ clay Plate	CL SC	100%	M		60	40	PID:0.0
58				DF : med Fine sand, clay Plate	SC		M		80	20	
60				Clay High Plasticity	CH		D			100	

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 1011mw023	Project Name: Building 1011 BAFB	Project #: 112000.0045.005
Construction Date: 4/26/06	Drilling Method: Auger	Casing/Screen Material: PVC
Geologist: C. Purcell	Checked By: D. Whitesides	Date: 5-30-06



COMMENTS:

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 3

LOCID: 1011 MW084			
Project Name: Building 1011 DAFTB	Project Number: 112000.0045	Date/Time Drilling Started: 4/28/06 0800	Date/Time Total Depth Reached: 4/28/06 1400
Drilling Company: Dakota Drilling	Driller: Gabe	Hydrogeologist: G Purcell	Total Depth Drilled: 60 / Total Depth Logged: 60
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs) First: NA / Final: 33.28 Blum 43.00 m 5/18/06 43.08 m 5/26
Type of Sampling Device: Split Spoon		Sample Hammer Type: NA Driving Wt. Drop	Checked by/Date: D. Whitesides 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
2				Fine sand moderate plasticity 10 YR 4/4	SW		D		100		PID: 0.0
4											
6				SAA	SW		D		100		PID: 0.0
8											
10				Fine sand, silt moderate plast. 10 YR 4/4	SM		D		80	20	PID: 0.0
12											
14				med to fine sand 10 YR 4/6 loose	SW		D		100		
16				FINE to coarse sand loose 7.5 YR 4/6	SW		D		100		PID: 0.0
18											

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Lithology Log (continued) Sheet 2 of 3

LOCID 1011 MW 04 ~~08~~

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				med to coarse sand loose 7.5 YR 4/6	SW		D		100		
22											
24				Fine sand mod. Plast. 10YR 4/6	SW		D		100		
26				Fine sand, clay mod. Plast. 10YR 5/4	SC		D		60	40	PID: 0.0
28											
30				Clay High Plasticity 10YR 5/2	CL		D			100	
32											
34											
36				med to coarse sand loose 10YR 5/6	SW		D		100		PID: 0.0
38				Clay, High Plasticity 10YR 5/1	CL		D			100	
40				DF Clay fine sand loose Platy	CL		M		40	60	
42											
44											
				SAA	CL		M		40	60	

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Lithology Log (continued) Sheet 3 of 3

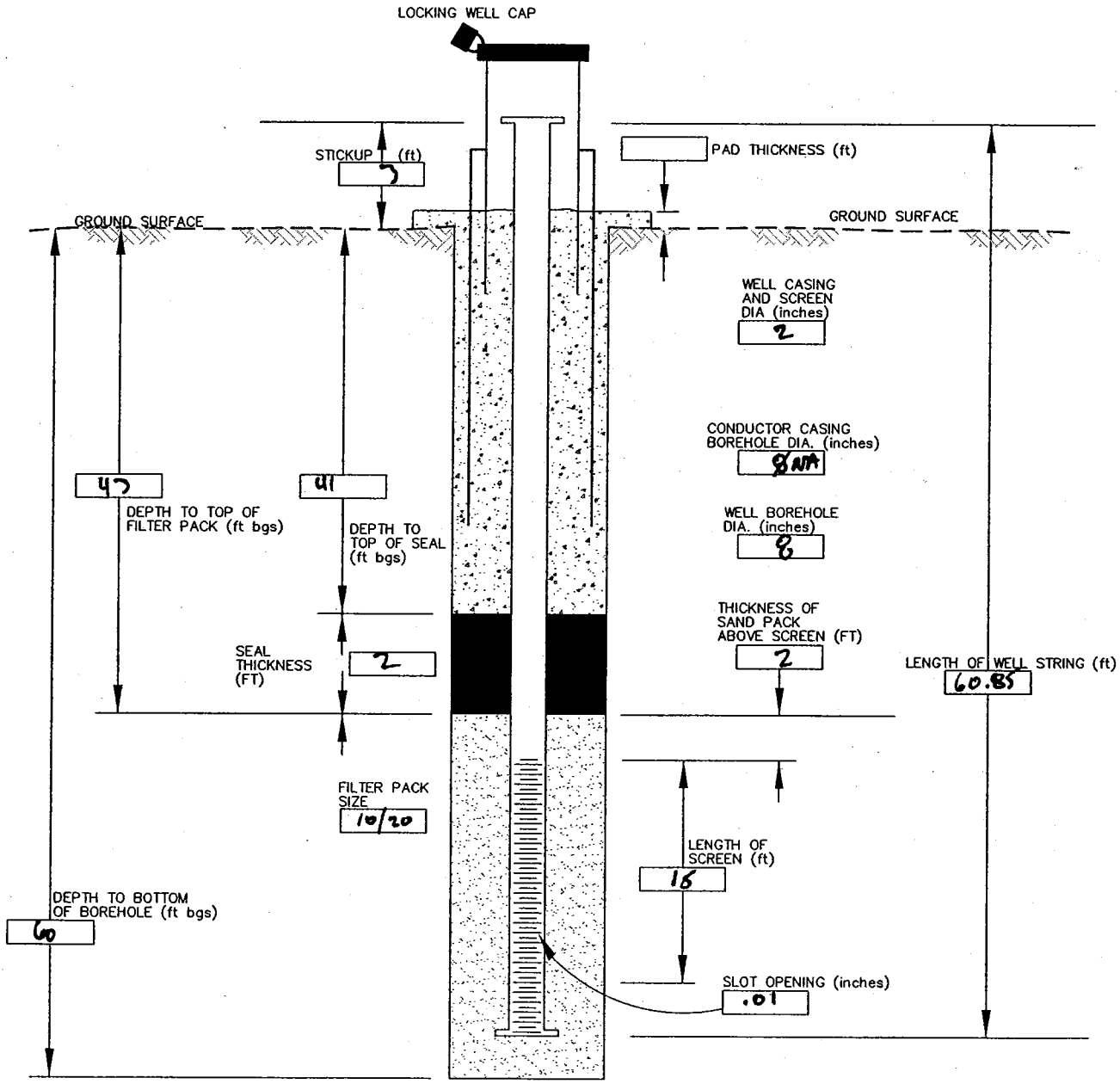
LOCID 10 11MW 04 08

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				coarse to med sand loose Gley 2 5/5PB	SW		m		100		PID 0.0
48				DF Clay High Plasticity	CH		D			100	
50				DF Clay, Fine sand Platy	~~CH~~ CH-CL		m		40	60	
52											
54				DF Clay High Plasticity	CH		D			100	PID: 0.0
56				DF Clay, Fine sand Platy	CH-CL		m		40	60	
58				DF Clay High Plasticity.	CH		D			100	
60											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 1011MW0984	Project Name: 112000.0045.005	Project #: Building 1011 BAFB
Construction Date: 4/28/06	Drilling Method: Auger	Casing/Screen Material: PVC
Geologist: C. Purcell	Checked By: D. Whitesides	Date: 5-30-06



COMMENTS: Approximate depths

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 1011mw05			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/2/06 1100	Date/Time Total Depth Reached: 5/2/06 1400
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 40 / Total Depth Logged: 40
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs): First NA / Final 28.68 on 5/25/06
Type of Sampling Device: Split Spoon		Sample Hammer: Type NA / Driving Wt. / Drop	Checked by/Date: D. Whiteside, 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				med to coarse sand, silt loose 10YR 4/3	SM		D		80	20	PID: 0.0
2											
				Fine sand, clay low plasticity 10YR 3/4	SC		D		80	20	
4											
				Fine sand, clay loose 10YR 6/4	SC		D		80	20	PID: 0.0
6											
8				Clay, Fine sand High plasticity 10YR 4/4	CL		D		20	80	
10				Fine sand, clay loose 10YR 4/3	SC		m		80	20	
12											
14				Clay High plasticity 10YR 4/2	CH		D			100	PID: 0.0
16				SAA	CH		m			100	
18				Fine sand High Plasticity 10YR 3/4	SW		m		100		

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Lithology Log (continued) Sheet 2 of 2

LOCID 101MW09

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
22				Fine sand, clay Platy 10YR 4/4	SC		M		80	20	
24				Fine sand, clay High Plasticity 10YR 3/3	SC		D		80	20	P.D:.1..
26				Fine sand, clay Platy (DF) Gley 2 -/5B	SC		M		80	20	
28											
30				med to coarse sand, clay Platy 10YR	SC		M		80	20	P.D:.0..
32				Dense Blue mixed with Sand 10 TR 3/3 lenses High Plasticity	CH		W		20	80	
34											
36				coarse sand, with clayless clay 2/5 B	SC		W		80	20	
38											
40				Clay High Plasticity DF	CH		D			100	
42											
44											

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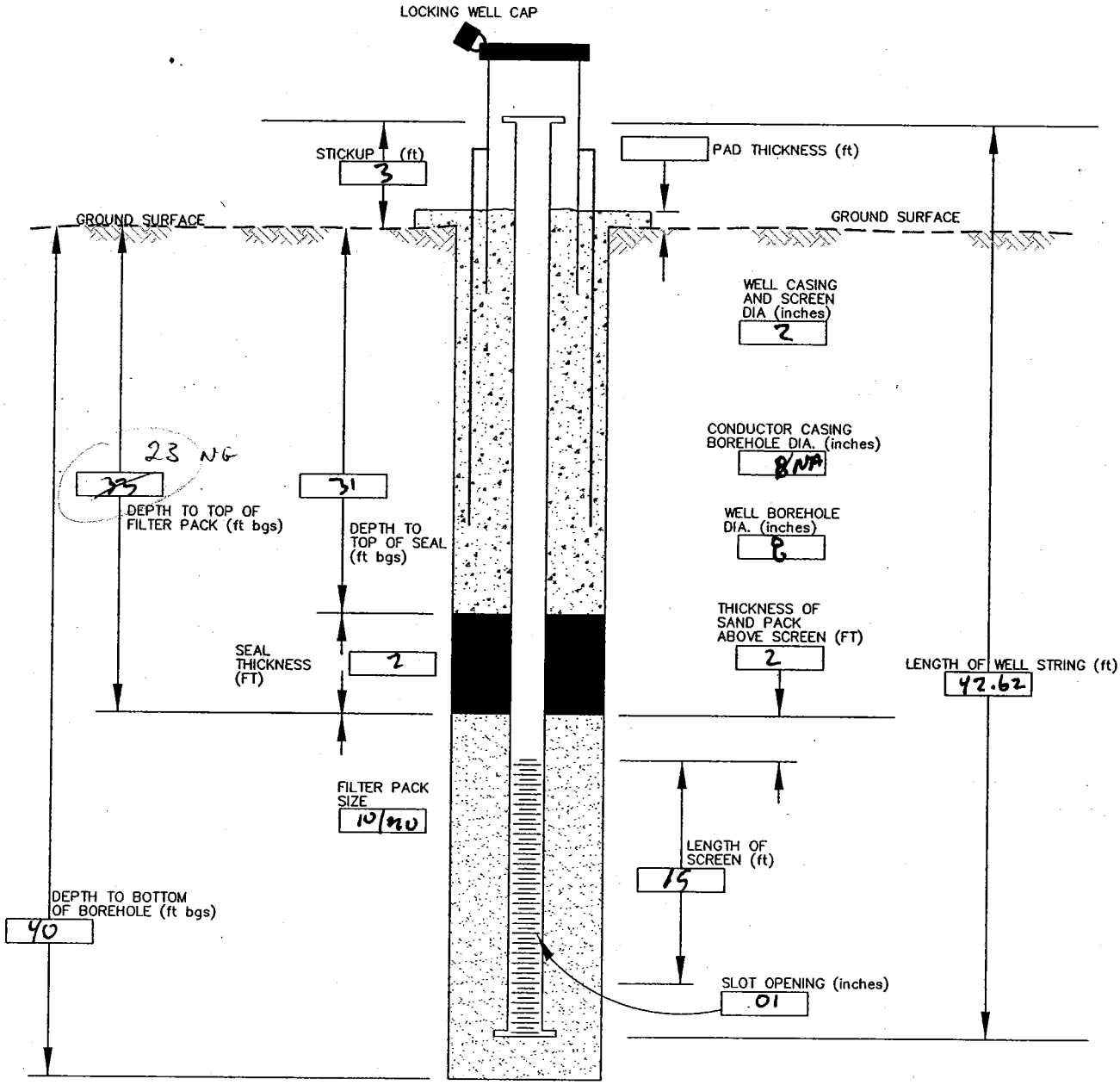
WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 1011mw05	Project Name: Building 1011 BAFD	Project #: 112000.0045.005
Construction Date: 5/2/06	Drilling Method: Auger	Casing/Screen Material: PVC
Geologist: C. Purcell	Checked By: D. Whitesides	Date: 5-30-06



COMMENTS: Depths are approximate

filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 1011mw60 MW06			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/2/06 0730	Date/Time Total Depth Reached: 5/2/06 1100
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 30 / Total Depth Logged: 30
Drilling Equipment: CME66	Drilling Method: Auger	Borehole Diameter: 8"	Water Level (bgs): First NA / Final ~~25.30~~ 25.29 on 5/19/06
Type of Sampling Device: Split Spoon		Sample Hammer: Type NA / Driving Wt. / Drop	Checked by/Date: D. Whiteside, 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine to ~~Coarse~~ med sand, silt loose 10YR 3/6	SM		M		80	20	PID: 0.0
2											
4				Coarse to med sand loose 10YR 6/4	SW		D M		100		
6				SAA	SW		M		100		PID: 0.0
8											
10				SAA	SW		M		100		
12				Fine sand low plasticity 10YR 3/4	SW		D		100		PID: 0.0
14											
16				Fine sand loose 10YR 4/6	SW		M		100		
18											

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Lithology Log (continued) Sheet 2 of 2

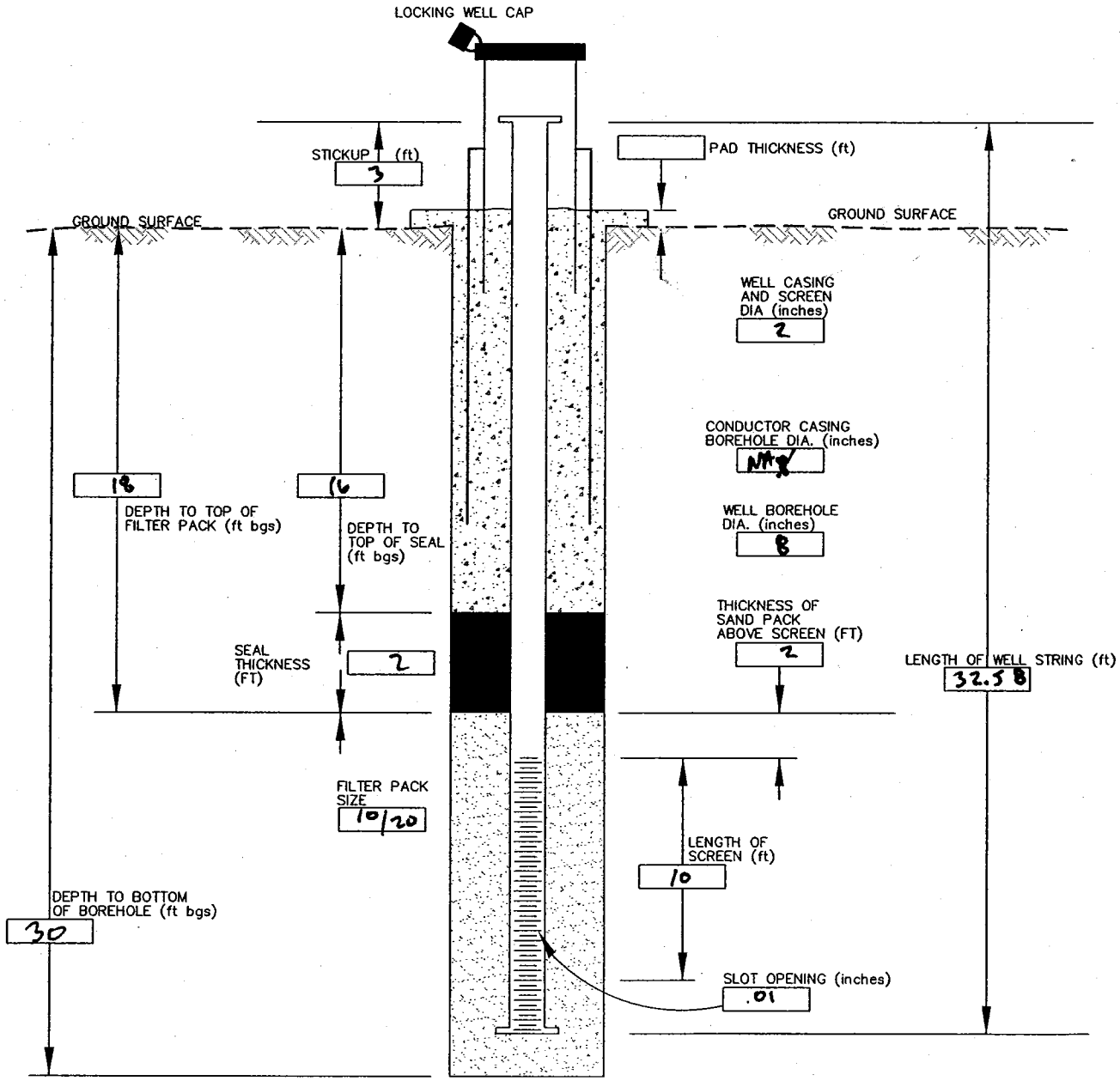
LOCID 1011MW06

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Med to fine coarse sand loose 10YR 4/6	SW		M		100		PID:0.0
22											
24											
				Coarse sand loose 10YR 7/8	SW		W		100		PID:0.0
26											
28				Clay High plasticity 10YR 3/3	CH		D			100	
30											
32											
34											
36											
38											
40											
42											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 1011 mw6	Project Name: Building 1011 BAFTS	Project #: 112000.0045.005
Construction Date: 5/2/06	Drilling Method: Auger	Casing/Screen Material: PVC
Geologist: C. Purcell	Checked By: D. Whitesides	Date: 5-30-06



COMMENTS:

filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 1011MW07			
Project Name: Building 1011 BAFD	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/5/06 0730	Date/Time Total Depth Reached: 5/5/06 1400
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 40 / Total Depth Logged: 40
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8	Water Level (bgs): First NA; Final 27.83 on 5/24/06, 30, 29.55 on 5/25/06
Type of Sampling Device: Split spoon		Sample Hammer: Type NA, Driving Wt., Drop	Checked by/Date: D. Whitesides 5.30.06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				coarse to med sand, pebbles loose 10YR 5/4	SW		m	20	80		PID: 0.0
2				Asphalt layer							
				med to coarse sand, loose 10YR 4/6	SW		m		100		PID: 0.0
4											
6				med to fine sand loose 10YR 5/6	SW		m		100		PID: 0.1
8											
10				SAA	SW						
12				med to fine sand 10YR 3/1	SW		D		100		slight staining slight odor PID: 23.0
14				Fine sand, silty low plasticity 10YR 4/6	SC		D		60	40	PID: 10.1
16				SAA	SC		D		60	40	PID: 26.1 NO staining Strong odor
18				Clay, fine sand High Plasticity 10YR 6/8	CL		D		20	80	PID: 3.1

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Lithology Log (continued) Sheet 2 of 2

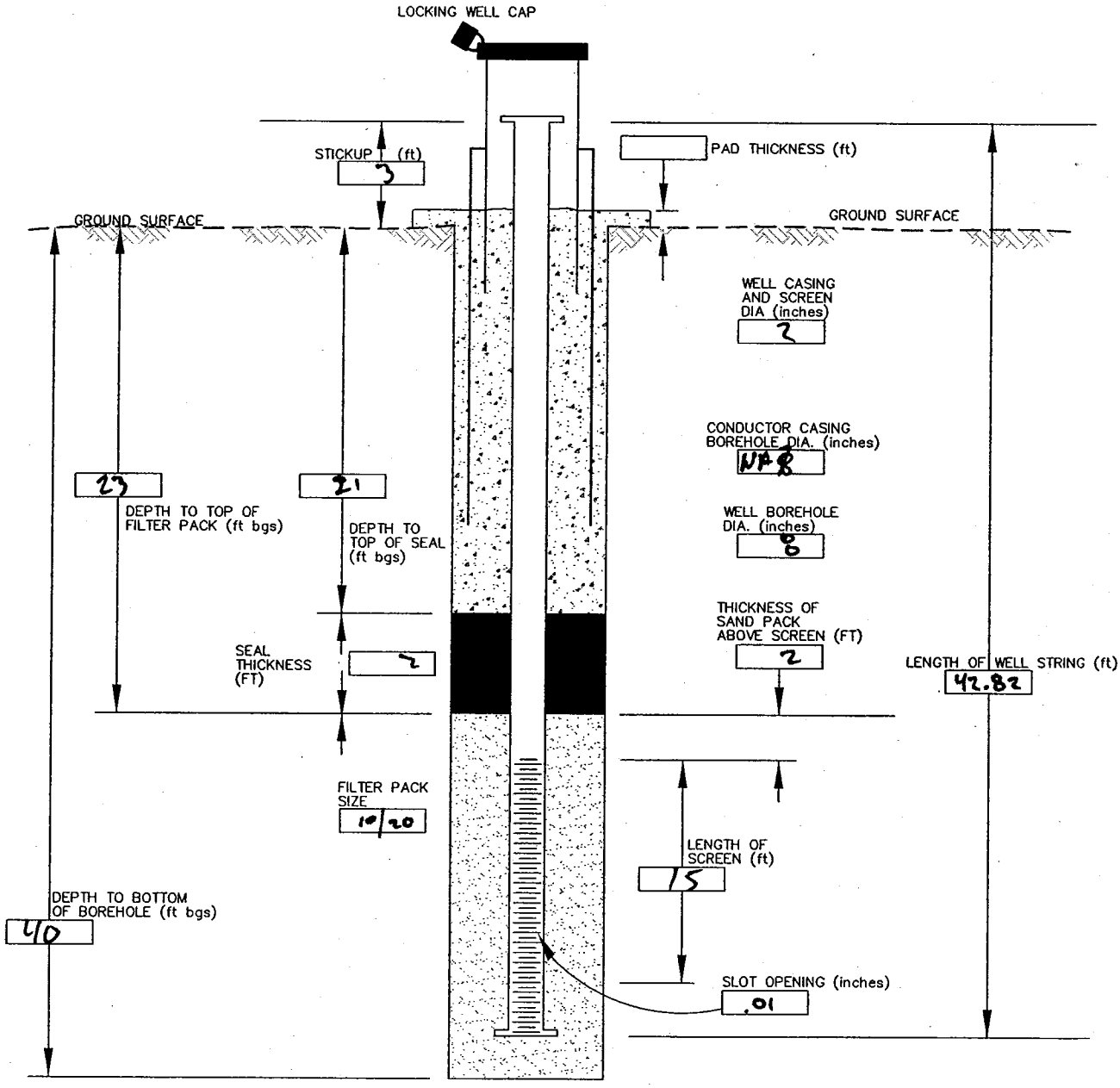
LOCID 1011mw03 MW07

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine sand clay loose 2.5Y 6/4	SC		D		80	20	PID : 10.6
22											
				Clay High Plasticity 2.5Y 5/6	CH		D			100	PID : 0.0
24											
				Fine sand, clay plasty 2.5Y 5/6	SC		D		60	40	PID : 0.0
26											
28											
30				SAA	SC		M		60	40	PID: 0.0
32											
34											
36				med to Fine sand loose 10YR 4/4	SW		W	100			PID: 0.0
38				DF Clay High Plasticity Gley 2 5/5B	CH		D			100	
40											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
1011MW07	Build 1011 DAFB	112000.0045
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/9/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-30-06



COMMENTS:

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 3

LOCID: 1011MW08			
Project Name: Building 1011 BAFD	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/3/06	Date/Time Total Depth Reached: 5/4/06
Drilling Company: Dakota Drilling	Driller: G. Ke	Hydrogeologist: G Purcell	Total Depth Drilled: 60 / Total Depth Logged: 60
Drilling Equipment: CME 66	Drilling Method: Auger.	Borehole Diameter: 8'	Water Level (bgs) First: NA; 23.93 on 5/19/06 Final: 27.40 on 5/25/06
Type of Sampling Device: Split spoon	Sample Hammer Type: NA	Driving Wt. / Drop	Checked by/Date: D. Whitesides 5-30-06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Concrete							
				Asphalt							
2				Coarse sand loose 10 YR 5/4	SW		m		100		PID 10.0
4											
6				SAA	SW		m		100		PID: 0.0
8											
10				SAA	SW		m		100		PID: 0.0
12											
14											
16				Coarse sand loose. 10YR 4/6	SW		w		100		PID: 0'
18				Clay High Plasticity 10YR 5/2	CH		D			100	

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Lithology Log (continued) Sheet 2 of 3

LOCID 1011MW08

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
22				Fine sand, clay platy 2.5Y 5/4	SC		D		60	40	PID:0.0
24											
26				med to fine sand, clay Platy 2.5Y 5/4	SC		D		60	40	
28											PID : 0.0
30				Clay, Fine sand, Black organics High Plasticity 2.5Y 5/1	CH		D		20	80	
32				Fine sand, clay Platy DF to 10YR 4/6	SC		D		80	20	
34				med to Fine sand loose Clay lens 10YR 3/6	SC		M		80	20	PID: 0.1
36				DF Clay, fine sand High Plasticity	CH		D		20	80	PID: 0.0
38											
40				DF Platy Clay, fine sand	CH		D		20	80	
42											
44											
				STOP							

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Lithology Log (continued)

Sheet 3 of 3

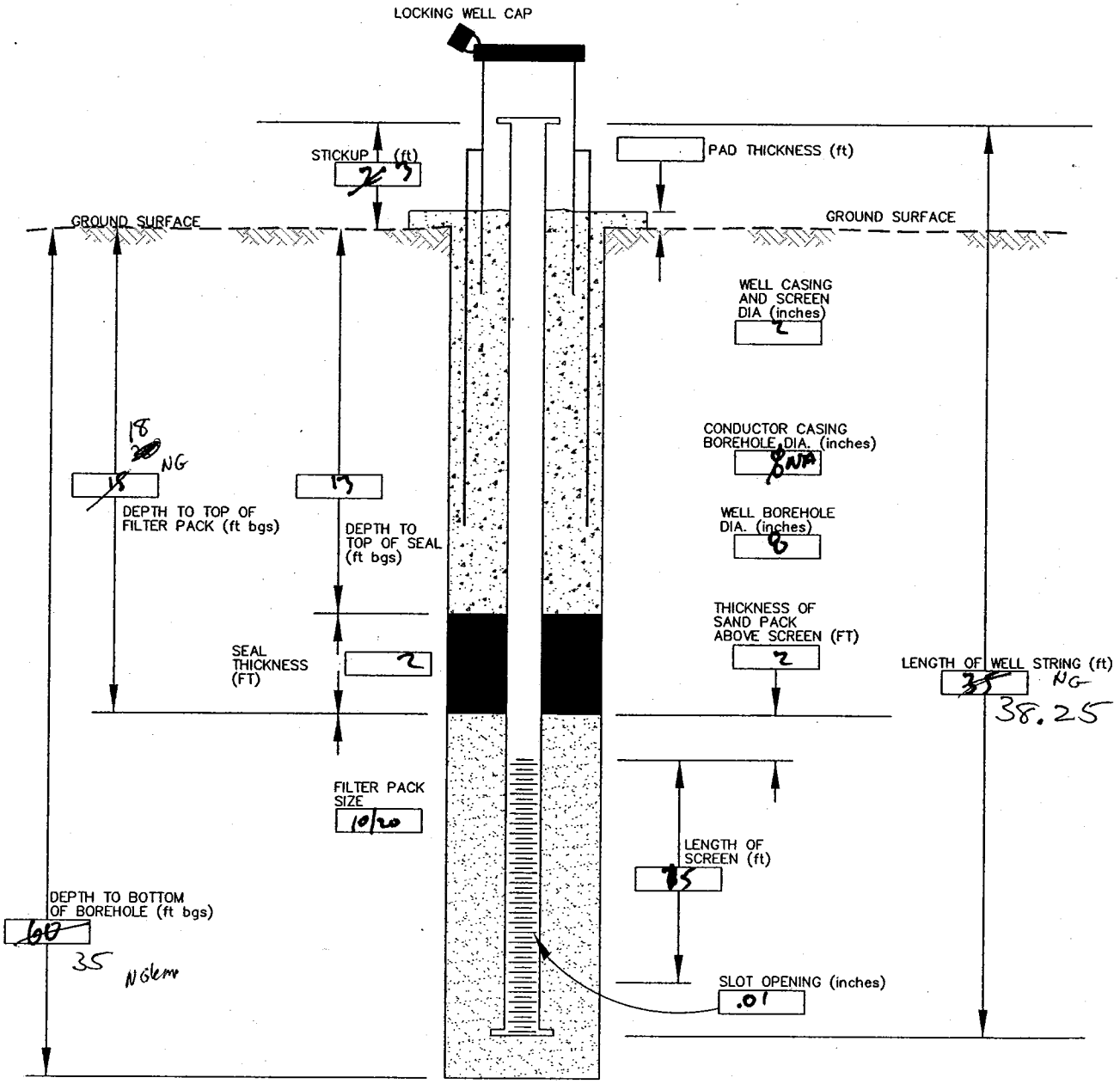
LOCID: 101MW08

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Denver formation	CH		D		20	80	
				Platy							
48				Clay, Fine sand							
50				SAA	CH						
52											
54											
56				SAA	CH						
58											
60											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
1011MW08	Building 1011 BAFD	112000.0045.005
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/4/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-30-06



COMMENTS: Borehole drilled to 60 ft. Backfilled to about 35 feet and set 15 ft screen

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 710mw01			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 4/27/06 0900	Date/Time Total Depth Reached: 4/27/06 1200
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 42 / Total Depth Logged: 42
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8	Water Level (bgs): First NP / Final
Type of Sampling Device: Split spoon	Sample Hammer: Type NP / Driving Wt. / Drop		Checked by/Date: D. Whitesides 5-23-2006

Location Description (include sketch in field logbook)
upgradient well from product well

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
2				med. to coarse sand, silt. loose 10YR 4/4 dark yellow brown	SC		D		60	40	PID: 0.0
4											
6				coarse to med. sand, loose 10YR 7/3 very pale brown	SW		D		100		PID: 0.0
8											
10											
12				med. to coarse sand, silt loose 10YR 4/6 dark yellow brown	SC		M		80	20	PID: 0.0
14											
16				SAA	SC		M		80	20	
18				Clay, Fine Sand, moderate plasticity 10YR 6/3: Pale Brown	CL		D		40	60	PID: 0.0

Versar INC.

Lithology Log (continued)

Sheet 2 of 2

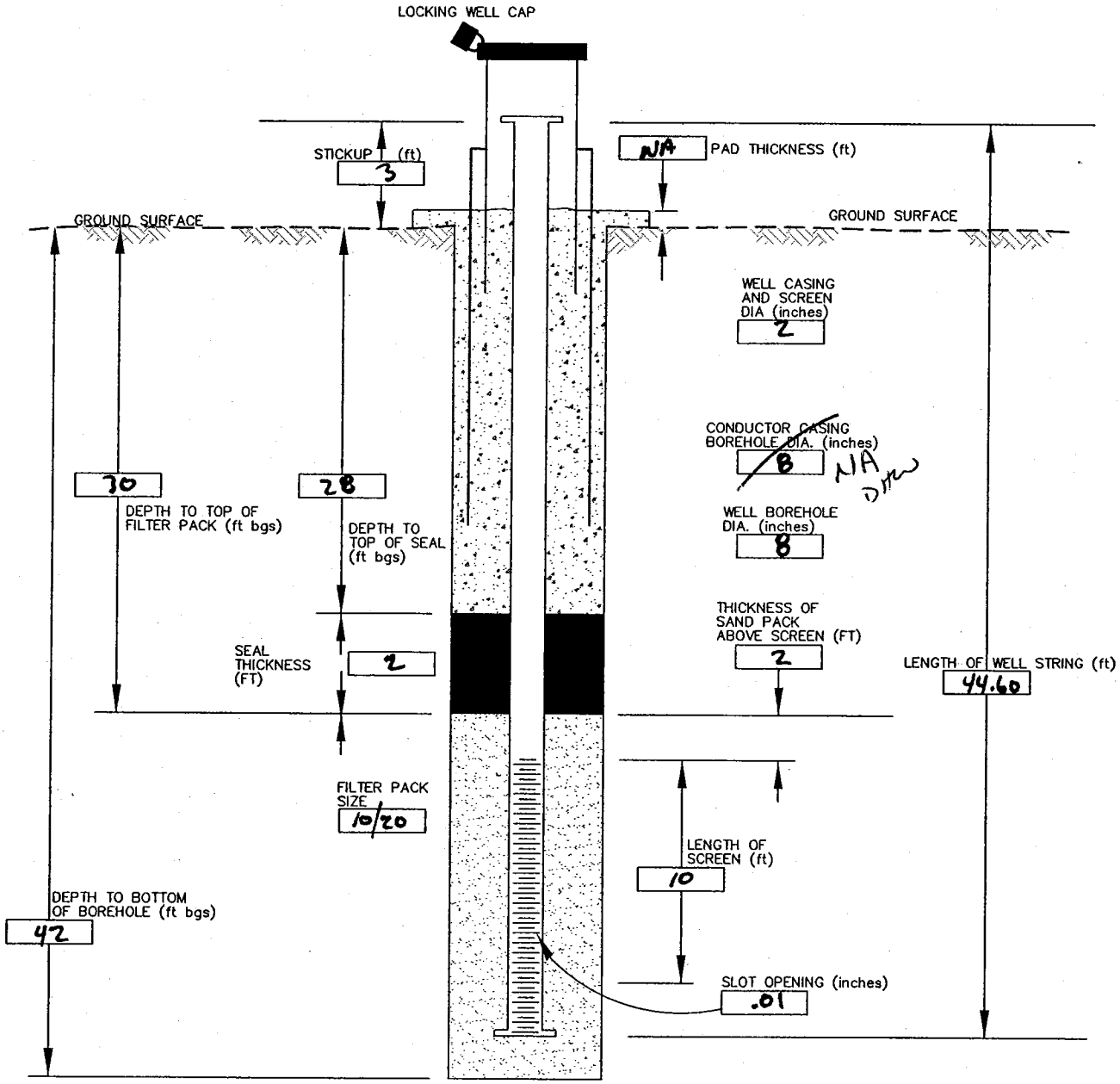
LOCID 710MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
22				Fine Sand, clay mod. to High plasticity 10 YR 4/2 dark grayish brown	SC		D		60	40	PID: 0.0
24											
26				SAA	SC		D		60	40	
				DF; clay, Fine sand High Plasticity	CH		D		20	80	PID: 0.0
28											
30				DF; clay High Plasticity	CH		M			100	
32											
34											
36				Fine to med. sand, clay loose 10 YR 4/6 dark yellowish Brown	SC		M		80	20	PID: 0.0
38											
40				SAA	SC		M		80	20	
42											
44											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
710MW01	Building 1011 BAFB	112000.0045.001
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
4/27/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5.23.06



COMMENTS:

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Lithology Log

Sheet 1 of 2

LOCID: 710MW02			
Project Name: Building 1011 BAFD	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/1/06 0800	Date/Time Total Depth Reached: 5/1/06 1200
Drilling Company: Dakota Drilling	Driller: C. Kessel	Hydrogeologist: C. Russell	Total Depth Drilled: 36 / Total Depth Logged: 36
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8	Water Level (bgs): First NA / Final
Type of Sampling Device: Split spoon	Sample Hammer: Type NA / Driving Wt. / Drop		Checked by/Date: D. Whitesides 5-23-06

Location Description (include sketch in field logbook)

Down Gradient well ≈ 15 ft.

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine to Coarse sand, silt loose 10YR 3/4 dark yellowish brown	SM		M		80	20	PID: 0.0
2											
4											
6				med. to Coarse sand, silt loose 10YR 5/4 Yellowish brown	SM		D		80	20	
8				Fine to med. sand, silt loose 10YR 3/1 very dark gray	SM		D		80	20	strong odor PID: 146.2 mod. staining
10				Coarse sand, clay Platy 10YR 7/1 light gray	SC		D		80	20	strong odor strong staining PID: 156.7
12											
14				clay, Fine sand moderate plasticity 10YR 5/4: yellowish brown	CL		D		40	60	PID: 70
16				Finesand, clay loose 10YR 5/1: gray	SC		D		60	40	slight odor PID: 136
18				clay, fine sand mod. Plasticity 10YR 5/3: Brown	CL		D		20	80	PID: 48.2

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Lithology Log (continued) Sheet 2 of 2

LOCID 710MW02

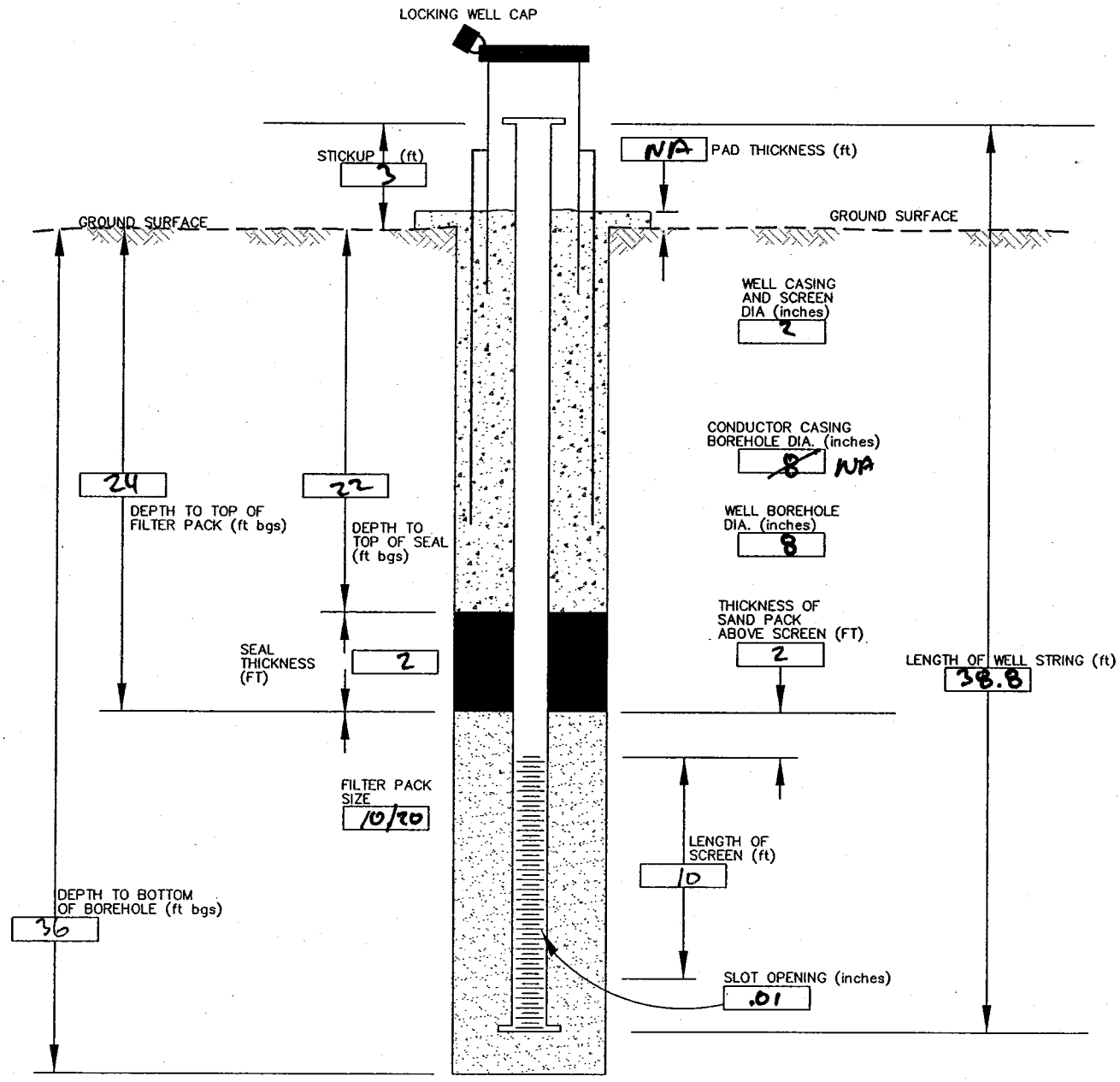
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine sand loose 10YR 5/4 : Yellowish Brown	SW		D		100		PID: 3.1
22											
24				Fine sand, clay mod. plasticity 10YR 7/6 : Yellow	SC		D		80	20	
26				SAA	SC		D		80	20	
28				DF, Clay Fine sand High Plasticity Gley 2 4/10BG : Dark Bluish gray	CH		D		20	80	PID: 1.9
30				med to Fine sand loose 10YR 5/6 : Yellowish Brown	SW		M		100		
32											
34				med to coarse sand loose	SW		W		100		
36				Claystone DF	CH		D			100	
38											
40											
42											
44											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

710MW02

Location ID:	Project Name:	Project #:
~~1011MW03~~ 710MW03	Building 1011 BAFD	112000.0048
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/1/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-23-06



COMMENTS:

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Lithology Log

Sheet 1 of 2

LOCID: 710 MW03			
Project Name: Building 1011 BAFD	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/1/06 1245	Date/Time Total Depth Reached: 5/1/06 1600
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 36 / Total Depth Logged: 36
Drilling Equipment: CME 66	Drilling Method: Auger	Borehole Diameter: 8	Water Level (bgs): First NR / Final
Type of Sampling Device: Split spoon		Sample Hammer: Type ND / Driving Wt. / Drop	Checked by/Date: D. Whitesides 5.23.06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine to coarse sand, silt loose 10 YR 3/4 : dark yellowish Brown	SM		D		80	20	PID: 0.0
2											
4											
6				Coarse to med. sand loose 10 YR 7/4 : very pale Brown	SW		D		100		PID: 1.3
8				Fine sand loose 10 YR 5/6 : yellowish Brown	SW		D		100		
10				SAA							
12				Fine sand, clay mod. plasticity 10 YR 4/4 : dark yellowish Brown	SC		D		60	40	PID: 0.7
14											
16				SAA	SC		D		60	40	
18				Fine sand, clay High Plasticity 10 YR 4/3 : Brown	SC		D		60	40	PID: 6.0

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Lithology Log (continued)

Sheet 2 of 2

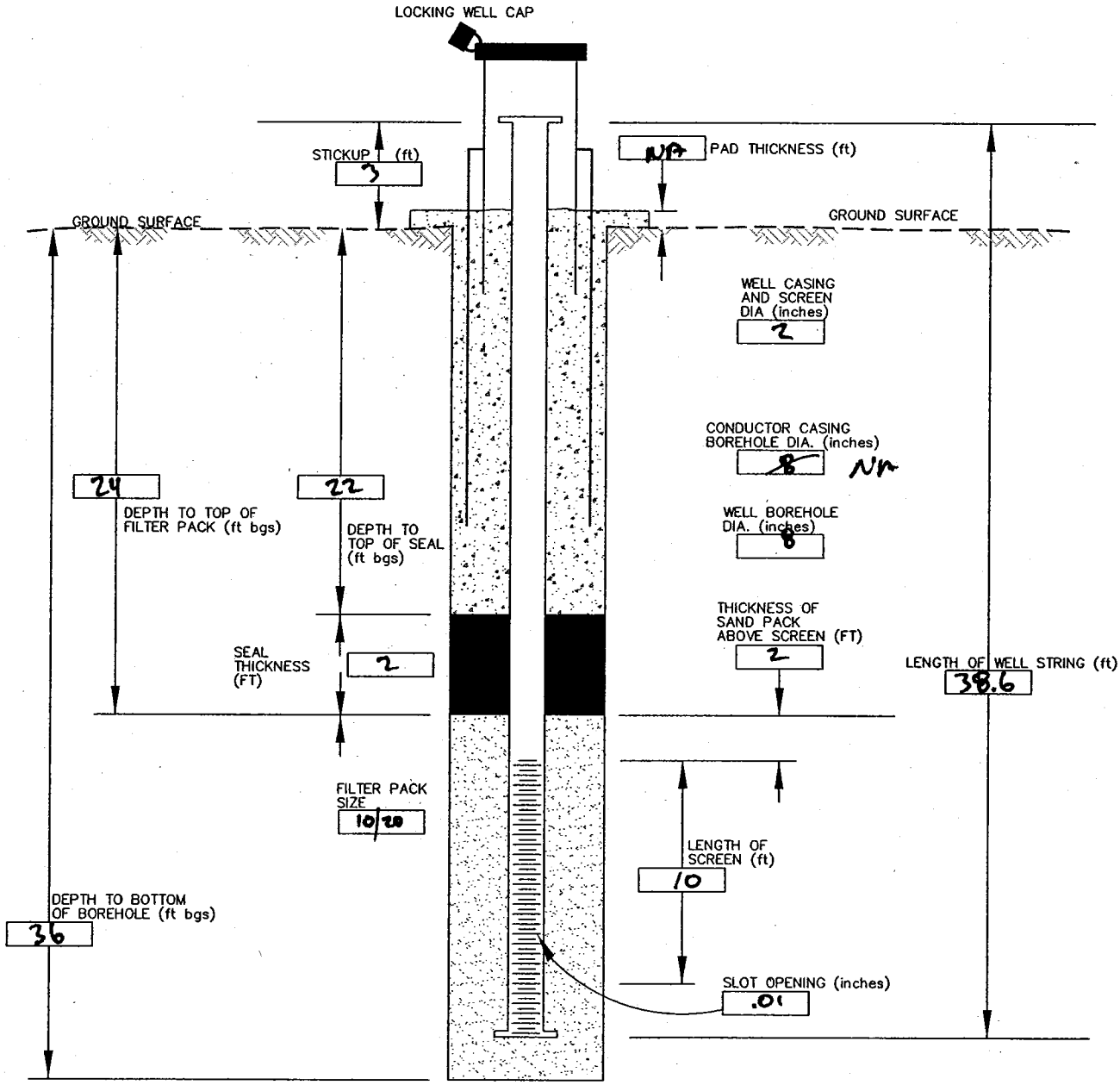
LOCID 710MW03

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine to med. sand, clay low plasticity 10 YR 4/6 : dark yellowish Brown	SC		D		80	20	
22											
				DF: Fine sand, clay High Plasticity Gley 2 5/5B : bluish gray	SC		D		60	40	PID:0.0
24											
				SAA							
26											
				Med. to Fine sand, loose 10YR 5/4 : yellowish brown	SC		D		60	40	PID:0.0
28											
				Fine sand, clay (DF) High Plasticity Gley 2.5/5 B : bluish black	SC		D		80	20	
30											
				med. sand loose 10 YR 4/4 : dark yellowish brown	SW		W		100		
32											
34											
				SAA	SW		W		100		
36				clay stone	CH		D			100	
38											
40											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
710 MW03	Building 1011 BAFB	112000.0045.005
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/1/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-23-06



COMMENTS: Approximate depths

filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 710MW04			
Project Name: Building 1011 BAFB	Project Number: 112000.0045.005	Date/Time Drilling Started: 5/3/06 0730	Date/Time Total Depth Reached: 5/3/06 1200
Drilling Company: Dakota Drilling	Driller: G. Kessel	Hydrogeologist: C. Purcell	Total Depth Drilled: 40 / Total Depth Logged: 40
Drilling Equipment: CME66	Drilling Method: Auger	Borehole Diameter: 8	Water Level (bgs): First NR / Final
Type of Sampling Device: Split Spoon		Sample Hammer: Type NA / Driving Wt. / Drop	Checked by/Date: D. Whitesides 5.23.06

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine to coarse sand, loose 10YR 5/4: Yellowish Brown	SW		D		100		PID: 0.0
2											
4											
6				coarse sand, pebbles loose 10YR 7/3: very pale Brown	SW		D	20	80		
8				med. to fine sand loose 10YR 4/4: dark Yellowish Brown	SW		D		100		PID: 0.0
10				SAA	SW		D		100		PID: 0.8
12											
14				Clay, fine sand mod. plasticity 10YR 4/2: dark Grayish Brown	CL		D		20	80	PID: 0.3
16				Clay, fine sand loose 10YR 4/2: dark Grayish Brown	CL		D		20	80	
18				Clay High plasticity 10YR 5/2: grayish Brown	CH		D			100	

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Lithology Log (continued) Sheet 2 of 2

LOCID 710mw04

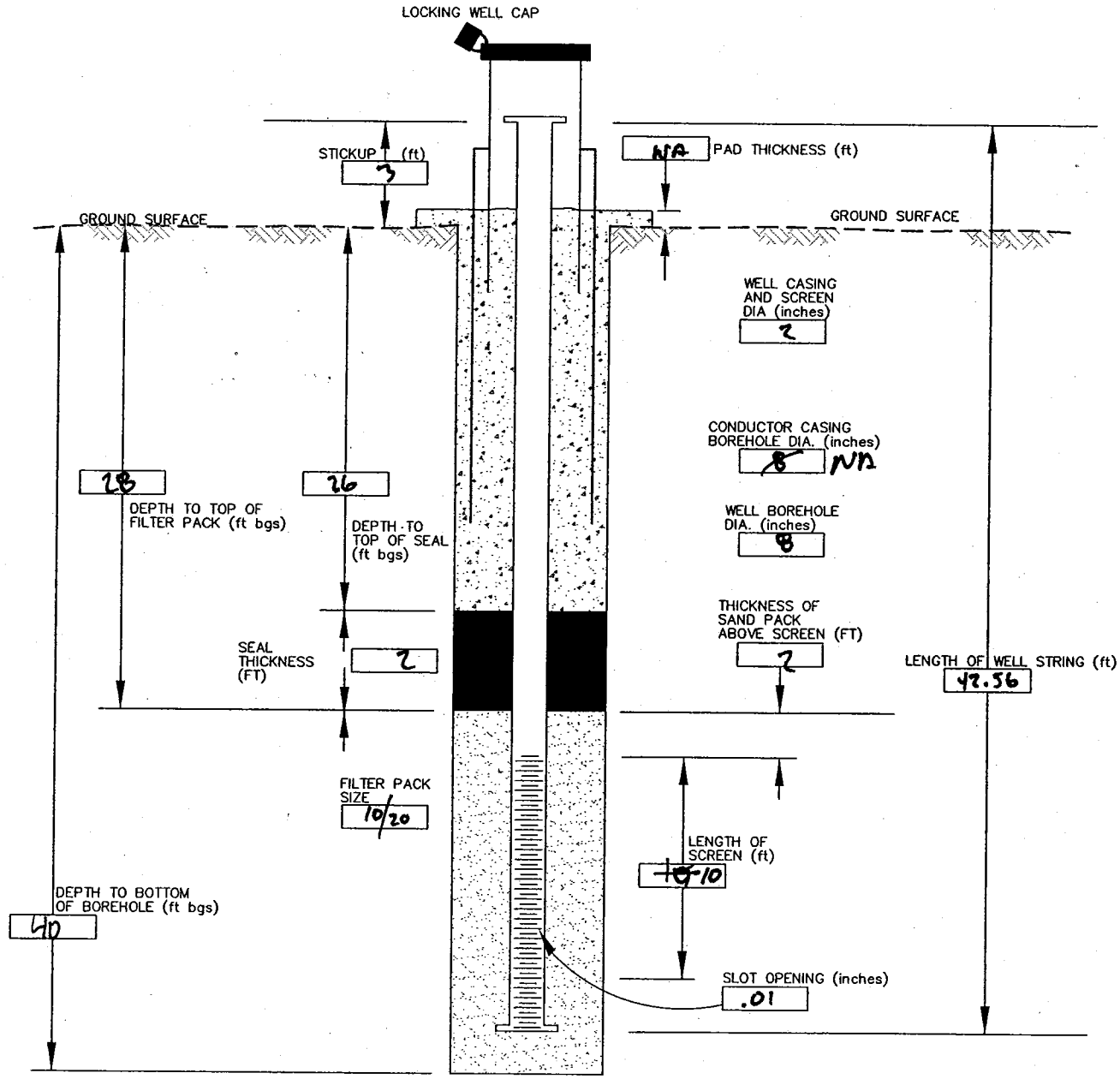
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Fine sand, clay Platy 10YR 5/6 : yellowish Brown	SC		M		80	20	PID:0.0
22											
24											
26				Clay, Fine sand. Platey 10YR 7/2 : light gray	CL		D		20	80	
28				Clay, Fine sand (DF) Platy Gley 2 6/10BG: greenish gray	CL		D		20	80	PID:0.0
30				SAA							
32				Fine to med sand 10YR 4/6 : dark yellowish brown	SW		W		100		
34											
36				SAA							
38											
40				Fine sand, clay mod. plasticity	SC		M		80	20	

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

710MW04

Location ID:	Project Name:	Project #:
~~710 MW05~~ ~~710MW04~~	Building 1011 BAFB	112000.0045.005
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/3/06	Auger	PVC
Geologist:	**Checked By:**	**Date:**
C. Purcell	D. Whitesides	5-23-06



COMMENTS: Approximate depths

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

BUCKLEY FIELD
MONITORING WELL BORING LOG

LFW-8

DEPTH (BLS)	ELEV (MSL)	LITHOLOGIC SYMBOLS	LAB SAMPLE NUMBER	DOWN PRESSURE (PSI)	TOP OF SAMPLE ('BLS)	BOTTOM OF SAMPLE ('BLS)	RECOVERY	SOIL TYPE (USCS)	LITHOLOGIC DESCRIPTION
0.0	5505			850	0.0	2.0	1.8'	ML	SILT, very fine sand, tr clay, tr coarse sand; w graded; dry; brown (10YR5/3).
				850	2.0	4.0	2.0'	SW	FINE SAND TO MEDIUM SAND, silt, tr clay; mod w graded; dry; brown (10YR5/3).
5.0	5500		LFW-8 4-6'	880	4.0	6.0	2.0'	ML	SILT, clay, fine sand, tr cobbles; w graded; dry; brown (10YR5/3).
				1200	6.0	8.0	2.0'	SP	FINE SAND TO VERY COARSE SAND, tr gravel, tr silt; pr graded; dry; drk brown (10YR4/3).
			LFW-8 8-10'	1200	8.0	10.0	2.0'	SP	same as above, sl moist.
10.0	5495			900	10.0	12.0	2.0'	SW	FINE SAND TO MEDIUM SAND, silt, tr clay, tr coarse sand; mod to w graded; sl plastic; v moist.
				900	12.0	13.5	1.0'	ML	SILT, fine sand, medium sand, clay, tr coarse sand; mod to w graded; sl plastic; v moist; yellowish brown (10YR5/4).
15.0	5490			1500	13.5	15.0	2.0'	SP	MEDIUM SAND TO VERY COARSE SAND (1.5'), CLAYSTONE/SHALE (0.5'), tr fine sand, tr iron stain; saturated; yellowish brown (10YR5/4) to drk brown (7.5YR4/2).
			LFW-8 15-16'	600	15.0	16.5	1.5'	SP	VERY COARSE SAND (0.2') AND CLAYSTONE/SHALE (1.3'); saturated; yellowish brown (10YR5/4) - drk brown (7.5YR4/2).
				900	16.5	18.0	1.5'		CLAYSTONE/SHALE, iron stain; soft; drk brown (7.5YR4/2).
20.0	5485			900	18.0	20.0	2.0'		same as above.
			LFW-8 20-21'	900	20.0	21.0	1.0'		same as above.

MONITORING WELL CONSTRUCTION SUMMARY

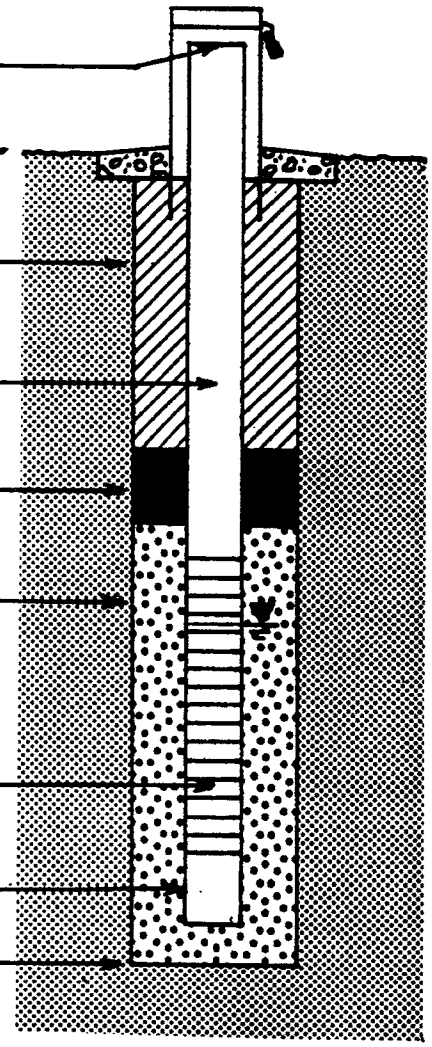
Science Applications International Corporation
An Employee-Owned Company

Well No.	:	LFW-8
Location (CO Coord.)		
Northings	:	82,631.4
Eastings	:	204,404.5
Reference Point	:	TOP OF PVC CASING
Reference Point Elev.	:	5506.47 MSL
Type of Security	:	STEEL PROTECTIVE CASING W/LOCK
Supervisory Geologist	:	S. DOTY
Log Book/Page No.	:	1/89-100, 4/33-34
Drilling Company	:	BOYLES BROTHERS
Rig Type	:	HOLLOW-STEM AUGER
Driller	:	D. STYLES
Drilling Started	:	11/06/88
Drilling Completed	:	11/06/88

Development		
Date	:	11/29/88
Type	:	BAILER
Volume Purged	:	72 GALLONS (PURGED DRY SEVERAL TIMES)
Water Level/Date	:	5492.09 01/19/89

MONITORING WELL AS-BUILT

		BLS	MSL
Top of PVC Flush Joint Riser w/PVC Cap Within Locking 8-inch Protective Casing		-1.5	5506.47
Land Surface		0.0	5505.0
Cement/Bentonite Grout	Top	0.0	5505.0
	Bottom	3.7	5501.3
4" I.D. Schedule 40 PVC Flush Joint Riser	Top	-1.5	5506.47
	Bottom	8.2	5496.8
Bentonite 1/4" Pellet Seal	Top	3.7	5501.3
	Bottom	5.7	5499.3
Sand Pack	Top	5.7	5499.3
	Bottom	21.0	5484.0
Static Water Level	01/19/89	12.9	5492.09
4" I.D. Schedule 40 PVC Flush Joint Screen 0.040" Slot	Top	8.2	5496.8
	Bottom	18.2	5486.8
Bottom Plug		19.2	5485.8
12" Borehole Total Depth		21.0	5484.0



All measurements in feet unless otherwise noted.
BLS - Below Land Surface
MSL - Mean Sea Level

NOT TO SCALE

LOG OF BORING NO. MW-6 (B-6)

CLIENT Triconsultants
PROJECT NAME Buckley ANG Phase I ESA w/subsurface sampling
PROJECT LOCATION Buckley
BORING LOCATION See Boring Location Map
SUBCONTRACTOR Drilling Engineers
INSPECTOR E. Schoedel

JOB NO. 41-0792-00024
START DATE 02/17/92
FINISH DATE 02/17/92
BORING METHOD HSA
ROCK CORE DIA. ____ IN.
SHELBY TUBE DIA ____ IN.

SOIL/ROCK DESCRIPTION Surface Elevation	STRATUM DEPTH Ft.	DEPTH Ft.	SAMPLE NO.	SPT N-value	PID ppm	BORING AND SAMPLING NOTES
Brown-gray silty sandy CLAY. Dry, medium stiff			B4-1	4,3,6	354	
	7′					
Dry dark gray Dry hard CLAY		10	B4-2	10,31,50	287	
	12′					
Dry tan-gray silty CLAY.			B4-3	14,27,30	179	Grout
	20′	20				
Dry dark medium gray silty CLAY			B4-4	20,21,32	183	2′ Bentonite
	30′	30				17′ Sand
Dark gray CLAYSTONE			B4-5	21,32,50	8.8	15′ Screen
		40				
Bottom of test boring @ 45′			B4-6	50/4	7.2	
		50				
		60				
		70				

WATER LEVEL OBSERVATIONS
NOTED ON RODS 35.0 FT
AT COMPLETION 35.0 FT
AFTER 2 Days 31.2 FT

BORING METHODS
HSA-HOLLOW STEM AUGERS
HA-HAND AUGER
CFA-CONTINUOUS FLIGHT AUGER

REC %: Sample Recovery, %
NR = No Recovery

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B1
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30'	Depth to Water (bgs)
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH/RB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location ~75' NW of Free Product well			Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
			0	ML		0-1.5 Dk Brown → Black organic stained sandy silt, moist loose	fill
2			0	ML		1.5-6 Brown → Red Brown sandy silt, some clay, loose, moist	
4			0				
6	16		1.1	SW		Red Brown Sand, few silt, loose, med coarse w/ some fine sand, well Graded, Sub Ang → Sub Round, SI moist	
8							
10	22		1.2				
12			1.1	SS (SP)		Yllw Red weathered Sandstone, variably cemented, med → fine grained, micaceous, moist	Denver FM
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LDC-B1

Depth (ft-bgs)	SAMPLES: Blows/Foot	SAMPLES: Recovery (ft)	SAMPLES: PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16			56	SS (SP)		As above, slight Hydrocarbon odor	Petroflag test kit sample = 46 ppm
18							
20	50/9		23	SS		As above, no odor, more cemented	
22							water @ ~23'
24							
26	50/14					As above	
28							
30						TD @ 30', set 2" temp well	
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B2
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30'	Depth to Water (bgs)
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH / RB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location ~75' E / NEat B1			Northing Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				ML		0-2 - Dk Brn Sandy Silt, loose, moist, few gravel clasts, Roots	
2			0				
				SW		Red/Brown Sand, few Silt, loose, med Coarse → fine, well graded, moist	
4			.9				
6							
8							
				SW		As above	
10	23		.8				
12							
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LDE-B2

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	36		2.1	SS ~~(SM)~~ (SP)		Red/Brown Silty Sandstone, weathered, micaceous, partially cemented	Petroleum no odor
18							
20	60/14"		1.6	SS (SM)		As above, more silt, partially cemented, moist	no odor
22							
			1.2			cuttings	
24						As above, wet	
	63		1.3	SS (SM)			
26				SISTONE (ML)		olive siltstone, few sand + clay, firm → hard, sl moist moist	
28							
30						As above TD @ 30', set 1" PVC	
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B3
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30'	Depth to Water (bgs)
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH / KB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location ~100' W/SW of B1			Northing Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				ML		0-3 DK Brn → Black Sandy silt, few gravel, sl moist	~~Asphalt~~ Carbon/ organic material in soil
2							
4				SW		Red Brn Sand, silty, w/ few clay, well graded, moist	
6							
8							
10	21	1½	1.1	SW		As above, more silt	no odor
12							
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LDC-B3

Depth (ft-bgs)	SAMPLES: Blows/Foot	SAMPLES: Recovery (ft)	SAMPLES: PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	38		1.3	SS		Yellowish Red Sandstone, loose → firm, sl moist	Petroleum odor
18							
20	32					olive → Lt Gray Claystone, sl moist, firm,	no odor
22							
24							?
26	60/14					Red-Brown Silty Claystone, few sand, sl moist, some wood fragments	
28							
30	42					As above, trace sand TD @ 30'. Backfilled to 25', set 1" Temp well	
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B4
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30'	Depth to Water (bgs) 24'
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH / RB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location			Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				ML		0-1.5 Dk Brown Sandy silt, few gravel, moist, loose	fill
			0.9				
2						Yellow/Red → Pink sand, coarse, sub ang, sl moist	
				SP			
4							
6							
8							
10			0.8	SP		As above, less coarse sand	no odor
12							
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LAC-B4

Depth (ft-bgs)	SAMPLES: Blows/Foot	SAMPLES: Recovery (ft)	SAMPLES: PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	22			SW		Yellow Red Sand, well graded, sl moist	no odor Denver Fm?
18							
20	36			SS (SM)		Red Brown Silty Sandstone, weathered, moist, w/ lignite seams (~1/4"), micaceous	Denver Fm no odor
22							
24	50/3"			SS (SM)		As above, partially cemented, wet	
26							
28							
30	50/6"					As above, TD @ 30', set 1" Temp well	
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-05
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30'	Depth to Water (bgs) 25'
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH / RB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location By old USTs			Northing Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				ML		0-1 Grey Sandy silt	fill
			0.7				
2				SW		Pink -> Yellow Red Sand, well graded, loose, slmoist	
4							
6							
				SW			
8							
						As above, alternating layers of different sizes of sand	No odor
10	23		1.1				
				SW			
12							
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LDC-B5

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	20		0.7	SW		As above, few gravels, 7% silts	no odor
18							
20	60/7"		1.3	SS (SM)		Red-Brown weathered Sandstone, some silt, med fine, partially cemented	Dense Fm
22							
24							
26	48		0.4	SS (SM)		As above, more silt	
				CLST (CL)		Olive → grey Claystone, w/ FeOx staining on fracs	
28							
30	45		0.7			As above, wet TDB 30' Set 2" PVC Temphell	
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B6
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 30' DMC 25'	Depth to Water (bgs) 20'
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CH / RB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location 10' SE of Bld 1081 SE Corner			Northing / Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				ML		0-1 Grey → Brown Sandy Silt, w/ gravel, some asphalt clasts	Fill
			0.6				
2				SW		Yellow Red → Pink Sand, well graded, sl moist	
4							
6							
8							
10	41		0.8	SW		As above, few gravels	
12							
14							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LPC-B6
	Client: Buckley AFB	
	Project Number:	

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	32		1.2	SS (SW)		Pink → Red Brown ~~Sand~~ silty Sandstone, sl moist	Dancer Fm
18				CLST (CL)		Red Brown Claystone, Silty, w/ minor sand & silt lenses (1/4 - 3/4"), sl moist	
20			0.6				
22	76					Red Brown Sandstone, weathered → partially cemented, wet	
24							
26	60/4"		0.4			As above, more cemented	
						TD @ 25', set 2" PVC	
28							
30							
32							

URS Boring Log	Project Name: BLDC Investigation	Log of Boring LDC-B7
	Client: Buckley AFB	
	Project Number:	

Date(s) Drilled 2/19/05	Logged By DMC	Checked By	Total Depth of Borehole (ft) 25'	Depth to Water (bgs)
Drilling Method Solid-Stem Auger	Diameter of Borehole (in) 4"		Ground Surface Elevation (ft-msl)	
Drill Rig Type CME-75	Drilling Company V.E. / HPD		Groundwater Elevation (ft-msl)	
Driller's Name CHIRB	Sampler Type Split Spoon		Measuring Point Elevation (ft-msl)	
Description of Sample Location South - SW of Free Product Cell			Northing Easting	

Depth (ft-bgs)	SAMPLES Blows/6"	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
				SW		Yellow Red Sand, well graded, loose moist	
2							
4							
6							
8							
10	39	1	1.3	SW		As above, sl moist, Tr gravel	
12							
14							

URS Boring Log	Project Name: BLDC Investigation Client: Buckley AFB Project Number:	Log of Boring LDC-B7

Depth (ft-bgs)	SAMPLES Blows/Foot	Recovery (ft)	PID (ppm)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS
16	32		1.0			olive claystone, firm, Frox staining on fracs, Grey weathering, some sand, micaceous sl moist	Denver fm
18							
20	38		0.8			As above, 1" siltstone lens @ ~19', micaceous throughout, few sand, sl moist	
22							
24							
26	42		1.3			As above, less silt + sand, sl moist	no odor, Dry cuttings
28						TD @ 25' - left borehole open for water to come in	
30							
32							

APPENDIX B

REPORT OF LNAPL REMOVAL AND MONITORING THROUGH JUNE 2010

PRUDENT TECHNOLOGIES, INC.

ENVIRONMENTAL SERVICES

DATE: October 2010

MEMORANDUM FOR: 90 MW/EM
John Wright
6307 10th Cavalry Ave., Bldg. 321, Rm. 114
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FROM: Joseph Fernando, Ph.D.
Project Manager
Prudent Technologies, Inc.
4242 Medical Drive, Suite 7250
San Antonio, TX 78229

SUBJECT: Report of LNAPL Removal and Monitoring
Site 11, Buckley Air Force Base
Contract Number FA8903-08-D-8794, Task Order 0003

In partial fulfillment of Paragraph 12.4.2.1 of the SOW and CDRL A001D, Prudent Technologies, Inc. (Prudent) is submitting this updated letter report of LNAPL Removal and Monitoring through June 2010 at Site 11, Buckley Air Force Base (AFB), Colorado. The purpose of this updated letter report is to describe the monitoring of the migration of the LNAPL and groundwater levels through June 2010, in addition to the previously documented removal of the light nonaqueous phase liquid (LNAPL) from well MW710-1 and abandonment of the temporary groundwater monitoring wells. In addition, these data support a request to discontinue the LNAPL removal and monitoring program.

Previous investigations of this area were conducted as part of the Building 1011 Area of Concern (AOC), which was converted to an Installation Restoration Program (IRP) site (Site 11) in August 2007. This work was conducted in accordance with the *Final LNAPL Removal Work Plan, Site 11, Buckley Air Force Base* (Versar, 2007a). Until February 2009, the work was conducted under Versar's Contract Number FA8903-04-D-8692, Task Order 0024. A previous version of this report that included monitoring through February 2009 was submitted to the regulatory agencies for review; their comments are attached. In addition, a previous version that included monitoring through February 13, 2008, was included in Appendix A of the *Final Engineering Evaluation/Cost Analysis (EE/CA) for Site 11 Soil and Petroleum LNAPL* (Versar, 2008a).

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Background

The February 2007 *Final Triad Site Inspection Report for Building 1011 Area of Concern* (Versar, 2007b) identified areas of the AOC that require additional investigation work, those that require no further action, and others with recommendations for response actions. This letter report describes the work conducted to addresses one of the areas with recommended actions, the LNAPL Area (removal from a well), which is at the east end of the Building 1011 AOC. The other recommendations have been implemented separately, including removal actions for the Building 1011 firing tunnels and sump/sand filter and a Remedial Investigation (RI) to investigate chlorinated solvent groundwater contamination in other areas of the site, as described in the *Final Quality Program Plan for Site 11 (Building 1011 Area) Remedial Investigation*, the *Final Addendum to the March 2009 Final QPP*, and the *Final Second Addendum to the March 2009 Final QPP* (Versar and Prudent, 2009a, 2009b, and 2009c).

The work to address the LNAPL, as described in this letter report, began prior to development and finalization of the Site 11 EE/CA to help to monitor (e.g., quantitate) and document the apparent limited LNAPL mobility and recoverability, in addition to remove an expected limited volume of LNAPL. Although the LNAPL does not appear to be migrating or contributing to a dissolved-phase plume of contaminants at levels of potential concern based on the Triad Site Inspection (SI) analytical data, and the apparent original source of contamination (oil-water separator) does not remain, removal of this petroleum LNAPL was recommended. However, limited recovery was expected, because the LNAPL was found to be limited to a small area, present in only well MW710-1 during the Triad SI (Figure 1).

Well MW710-1 has historically had less than 1 to about 2 feet of petroleum LNAPL, characterized as weathered jet fuel (JP-8) and potentially heavy oil, floating on groundwater about 29 to 30 feet below ground surface (bgs). JP-8 is a kerosene-based fuel, which was developed to be less volatile and explosive than its predecessor, JP-4, a gasoline-based fuel. The apparent thickness of LNAPL at well MW710-1 was initially measured as about 10 inches (0.83 foot) in early December 2004, at an approximate depth of 29 feet bgs. The well was bailed until it was almost dry; the LNAPL appeared to take about 3 months to reenter the well bore at a measurable thickness (Table 1). No free product was measured on February 3, 2005; only a film was present on February 25, 2005; and 0.2 foot (about 2.4 inches) of product was measured on March 2, 2005. In April 2006, about 2 feet of product was recorded. Five surrounding monitoring wells (including one temporary well) were installed and sampled in April and May 2006 during the Triad SI. In June 2006, no LNAPL was identified in an upgradient well within 10 feet (710MW01), in a downgradient well within 15 feet (710MW02), or in three other wells installed in nearby down- and cross-gradient locations (710MW03, 710MW04, and SG21W). These wells were not monitored again until over a year later, in September 2007, as described below. Since the Triad SI was completed, one additional analytical groundwater sample has been collected from these wells; well 710MW03 was sampled under the Site 11 RI in June 2010. Consistent with the previous analytical data, and as described in the RI report, no chemicals associated with the previous Site operations have been found in the groundwater in the LNAPL area at levels that may pose an unacceptable risk.

September and November 2007 LNAPL Monitoring

On September 14, 2007, Versar used an oil-water interface probe to measure the apparent free product thickness in well MW710-1, and assess whether free product was present in any of the other wells in this area, including wells 710MW01, 710MW02, 710MW03, 710MW04, and SG21W (Figure 1). These wells were monitored for product and water levels again on November 15, 2007. Water and product levels were measured to the nearest 0.01 foot from the surveyed measuring point (the top of the well casing [TOC]). To minimize potential contamination, levels in the up- and down-gradient wells were measured first. The probe was decontaminated with a detergent solution before each use.

In well MW710-1, the apparent thickness of LNAPL was measured as about 0.3 foot in both September and November 2007. No free product was measured in the other wells. Water levels in these six wells were about 2.6 to 3 feet higher in September 2007 than measured in June 2006, ranging from about 25 to 31 feet below the TOC in September 2007 (Table 2, Figure 2). In November 2007, the water levels in these six wells were slightly lower (by 0.32 to 0.43 foot) compared to September 2007. The higher groundwater levels in the fall of 2007, compared to June 2006, may have caused the reduction in the apparent thickness of free product in well MW710-1, potentially due to compression of the capillary fringe. These observations further supported the conclusion in the *Final Triad Site Inspection Report for Building 1011 Area of Concern* (Versar, 2007b) that the extent and the mobility of the free product are limited.

Temporary Monitoring Well Abandonment

Six temporary wells installed in February 2005 (LDC-B1 through LDC-B6) that monitor perched groundwater in the area were proposed for abandonment in the LNAPL Removal Work Plan (Versar, 2007a), because they were no longer needed, and could be impacted by construction activities for the adjacent Leadership Development Center (LDC). In addition, temporary well SG21W was also proposed for abandonment. Perched water was previously measured in the LDC wells at about 18 to 20 feet bgs; groundwater in well SG21W was about 25 feet bgs in September 2007. Versar located five of these seven wells on September 14, 2007. Two wells (LDC-B3 and LDC-B6) could not be found, because the ground surface had been altered for the LDC construction traffic and trailer.

On December 18, 2007, water levels in wells LDC-B1, LDC-B2, LDC-B5, and SG21W were measured immediately before abandonment, as indicated in Table 2. The water-level probe could not be lowered into well LDC-B4 because the casing was slightly bent; previous water-level measurements for this well and current measurements for the nearby wells were used to estimate the water level. Wells LDC-B3 and LDC-B6 were not found on December 18, 2007, or on January 15, 2008, when the snow cover had melted and Versar returned with a hand-held recreational grade Global Positioning System (GPS) instrument to attempt to locate the wells. Therefore, no additional action will be taken for these two wells. Wells LDC-B1, LDC-B2, LDC-B4, LDC-B5, and SG21W were abandoned in accordance with Rule 16 of the Colorado Water Well Construction Rules. The abandonment was conducted in two phases because of the snow cover, and included filling the casing with sand to the water table and bentonite to about

3 feet bgs on December 18, 2007, and cutting off the casing near the ground surface and filling the upper casing with grout to the surface on January 15, 2008.

LNAPL Removal and Monitoring

On December 18, 2007, Versar mobilized to Site 11 to begin implementation of the LNAPL Removal Work Plan (Versar, 2007a). Water levels and product were measured in six wells in the area before the LNAPL was pumped from well MW710-1. The wells are MW710-1, SG21W, 710MW01, 710MW02, 710MW03, and 710MW04. The apparent thickness of LNAPL in well MW710-1 was again measured as about 0.3 foot. Measurements for well MW710-1 are included in Table 1; measurements for all wells are included in Table 2.

As directed by Versar, Thermo Fluids Inc. used a vacuum truck and a stinger pipe to pump out the free product from well MW710-1. Thermo Fluids Inc. also performed a chlorine field test on the product to confirm its suitability for recycling. A 1-inch-diameter polyvinylchloride (PVC) "stinger" pipe was lowered into well MW710-1 to the depth of the product, about 30 feet below the TOC, and used to remove the product at a slow rate in order to maximize product recovery. As the product and water were recovered, the stinger pipe was slowly lowered into the well to a depth of 35 feet below the TOC. After 30 minutes of product/water recovery, recovery slowed, and pumping was stopped for about 10 minutes to evaluate the amount of product and water recovered, and allow additional recharge into the well. Pumping was restarted and continued for about 40 minutes, following the initial procedure. Approximately 2 gallons of LNAPL and 38 gallons of water were recovered, based on the depth of the material and volume of the vacuum truck tank. The LNAPL is considered a recyclable material, so it is not a waste. It was used as burner fuel to heat up aggregate at an asphalt plant, and the water was taken to a water treatment facility operated by Arvada Treatment Center, LLC.

Following the pumping, a sorbent sock was placed in well MW710-1 for passive recovery of residual LNAPL. The sock has hydrophobic fill to collect hydrocarbons, and is about 1.5 inches in diameter by 15 inches in length. The capacity of the sock is approximately 0.1 gallon. About 1 to 2 inches of the sock was submerged in the water in the well, with the remainder extending above the water table.

Initially, the amount of free product being absorbed on the sock was checked twice at 1-week intervals, on December 26, 2007, and January 2, 2008. Because a minor amount of free product absorbed to the sock, and was not significantly different between the two visits, the next interval was changed to 2 weeks, and the well was checked again on January 15, 2008. Similarly, because there was no significant difference after 2 weeks, the well was checked again after 4 additional weeks, on February 13, 2008. Subsequent monitoring was conducted approximately quarterly, because of the limited water-level and LNAPL changes. These events were conducted April 25 and July 2, 2008 (10-week intervals); November 7, 2008 (18-week interval); February 19, June 1, and September 16, 2009 (15-week intervals). In addition, between February and June 2009, water levels were measured as part of the RI on April 8; these data are also included in this report. Another round of water-level measurements was conducted under the RI in June 2010; these data are also included in this report.

During the LNAPL monitoring events, wells 710MW01 through 710MW04 were gauged with an oil-water interface probe for the presence of LNAPL and depth to water, as documented in Table 2. Water levels were also measured in well MW710-1, and free product thickness in well MW710-1 was checked. The presence of the sock results in a negligible amount of free product in well MW710-1. LNAPL was not measured in any well during these events until November 7, 2008, when 0.02 foot of LNAPL was measured in well 710MW01 (Table 3). A sorbent sock was placed in this well on November 13, 2008. Previously (e.g., September and November 2007), odor had been noted on the probe, but no LNAPL was measured. No odor had been noted when monitoring the other wells (710MW02, 710MW03, 710MW04).

The amount absorbed onto the sock in well MW710-1 (based on length and absorbency of sock) during each monitoring period was documented to track and assess the amount of free product absorbed versus time and the change in water levels, as indicated in Table 4. Only a limited amount of hydrocarbon appeared to be absorbed during the more than 2 years after the LNAPL was removed from well MW710-1, including staining of about 0.3 feet (3.6 inches) at the base of the sock, and a narrow linear stain extending up one side of the sock, as shown in the attached photographs. After the initial placement and observation of absorption to the sock (one week after LNAPL removal), there did not appear to be a significant change in the amount absorbed. Based on the absorbency of the sock, and the length of the impacted portion of the sock compared to the total length, it is estimated less than 0.03 gallon of petroleum product has absorbed to the sock.

The amount absorbed onto the sock in well 710MW01 between November 13, 2008, when the sock was placed in the well, and February 19, 2009 (about 3 months), the first monitoring event, was similar to the total amount that had absorbed onto the sock in well MW710-1, as indicated in Table 4. Only a limited amount of hydrocarbon appeared to be absorbed, including light staining of about 0.3 foot (3.6 inches) at the base of the sock, and a narrow linear, gelatinous stain extending along one side of the sock, as shown in the attached photographs. During the next 7 months, through September 16, 2009, additional hydrocarbons appeared to be absorbed onto the sock in well 710MW01, as indicated in Table 4. Based on an estimated impacted length of about 0.45 foot (5.4 inches), it is estimated less than 0.04 gallon of petroleum product has absorbed to the sock.

Assessment of LNAPL and Water-Level Monitoring Data

Between April-May 2006 (when the LNAPL monitoring wells were installed under the Triad SI) and November 2008, the water levels in the five wells increased, rising from 2.3 feet in downgradient well 710MW04 to 3.5 feet in upgradient well 710MW01 (Figure 2). During the period from December 2007, after about 2 gallons of LNAPL were pumped from well MW710-1, and September 2009, the water levels in this well varied by 1.75 feet; however, no significant changes in the amount of LNAPL entering the well during this period were observed. The first measurement of LNAPL in well 710MW01, in November 2008, corresponded to the highest measured water levels since the Triad SI was conducted. The water level measured in September 2009 was the highest recorded in this well. However, only a limited amount has been present in this well (0.02 foot apparent thickness, less than 0.04 gallon absorbed to sock). This well is about 10 feet upgradient of the well with previously measured LNAPL (MW710-1), and

the former oil-water separator was between these two wells, indicating it is in the general area of the former source (Figure 1). Overall, the water levels have increased by about 4.5 feet since May 2006, based on measurements in the five wells in the LNAPL area.

As described and assessed in detail in the Final Site 11 EE/CA (Versar, 2008a), the detection of LNAPL in a well does not necessarily correlate with mobile and/or practicably recoverable product. Less than 0.03 gallon (e.g., 1/2 cup, 4 fluid ounces) of petroleum LNAPL has apparently entered well MW710-1 during the monitoring period of about 2 years, during which water levels fluctuated about 2 feet. A similar amount has entered well 710MW01. Rising and falling water table elevations tend to spread LNAPL about the water table. A rising or falling water table may promote entry of mobile LNAPL into areas not previously contaminated with these liquids or regions of lower LNAPL saturation. It is not uncommon to observe a "patchy" distribution of LNAPL over a relatively small area at a site, or the transient presence of LNAPL in a well (EPA, 1995). In addition, in fine-grained sediments, such as the clay characteristic of this area, the LNAPL is likely sparsely distributed along secondary features (e.g., sand seams, etc.) that are poorly connected (API, 2003). Therefore, consistent with the previous interpretation presented in the Site 11 EE/CA, it is unlikely additional significant LNAPL will be recovered from this area, even with water-level fluctuations. The previous calculations of saturation and volume in the Site 11 EE/CA indicated that, based on the range of the initial apparent thickness of LNAPL measured in well MW710-1 and the maximum reported apparent thickness, the estimated volume of LNAPL ranged from 0.326 to 4.57 gallons. This evaluation predicted the LNAPL is immobile and not likely to be recoverable. As described above, about 2 gallons were pumped from well MW710-1 in December 2007 and very little has been recovered from the wells since then.

Summary and Conclusions

The LNAPL site has been monitored for a period of over 2 years since LNAPL (about 2 gallons) was pumped from well MW710-1 in December 2007. Based on observations of a sorbent sock placed in this well, less than 0.03 gallon (e.g., 1/2 cup, 4 fluid ounces) of petroleum LNAPL has entered well MW710-1 during this monitoring period. LNAPL has been measured in only one other well in this area since the four surrounding wells were installed in April-May 2006. This well, well 710MW01, is about 10 feet upgradient of well MW710-1, and the former oil-water separator source was between these two wells. Only a thin apparent thickness (0.02 foot) of LNAPL was measured in this well, and less than 0.04 gallon has absorbed to a sorbent sock placed in this well. These observations indicate the conclusions in the Site 11 EE/CA (Versar, 2008a), as described below, are still valid. It is assumed that information from additional monitoring will not substantially alter these observations or conclusions.

As presented in the Site 11 EE/CA, based on the screening evaluation of sampling data collected at the LNAPL area, no chemicals associated with the previous Site operations are found at levels that may pose an unacceptable risk to current and future human populations, either through the vapor pathway or direct contact. The analytical data obtained for well 710MW03 in June 2010 under the RI support this previous conclusion. The LNAPL is immobile and not likely to be significantly recoverable. It is not a source of dissolved groundwater contamination above regulatory standards. Therefore, human health and ecological risks and

regulatory requirements do not drive remedial actions for the LNAPL in well MW710-1. Removal of about 2 gallons of LNAPL in December 2007 and subsequent passive removal by use of sorbent socks has further reduced any potential risk and impacts associated with the LNAPL.

Recommendations

This document presents the latest information collected for the LNAPL monitoring, which continues to support the observation that limited LNAPL is present in the area. Because of the small quantities of remaining LNAPL, and the absence of potential risk and dissolved impacts, there does not appear to be a reason to continue the LNAPL removal and monitoring program for this area. The attached regulatory agency comments on the previous version of this report, which included monitoring data through February 2009, indicated a request to discontinue the LNAPL removal and monitoring program for this area would be considered. Some of the wells may be retained for water-level monitoring purposes.

Upon regulatory approval to discontinue the LNAPL removal and monitoring program, the sorbent socks should be removed from wells MW710-1 and 710MW01 and properly disposed. In addition, wells not needed for water-level monitoring to support the Site 11 (Building 1011 Area) groundwater investigations will be abandoned. It is recommended that well 710MW03 be retained, and the other four LNAPL monitoring wells (710MW01, 710MW02, 710MW04, MW710-1) be abandoned,

If you have any questions, please call Nan Glenn, Versar, Inc. (Versar) Project Manager, at 303-450-1927, or myself at 210-822-9588. Thank you.

Attachments: Figure 1 – LNAPL Area Well Locations
Figure 2 – Groundwater Elevations Versus Time
Table 1 – Well MW710-1 Water-Level and Product Measurements
Table 2 – Historic and Current Water-Level Measurements
Table 3 – Well 710MW01 Water-Level and Product Measurements
Table 4 – Wells MW710-1 and 710MW01 LNAPL Removal Monitoring
Thermo Fluids Inc. Bill of Lading
Photographs
Regulatory Agency Comments

cc: Nan Glenn, Versar, Inc.

References:

American Petroleum Institute (API). 2003. *Answers to Frequently Asked Questions About Managing Risk at LNAPL Sites, Soil and Groundwater Research Bulletin Number 18. May.* (Accessed at http://www.api.org/ehs/groundwater/lnapl/index.cfm)

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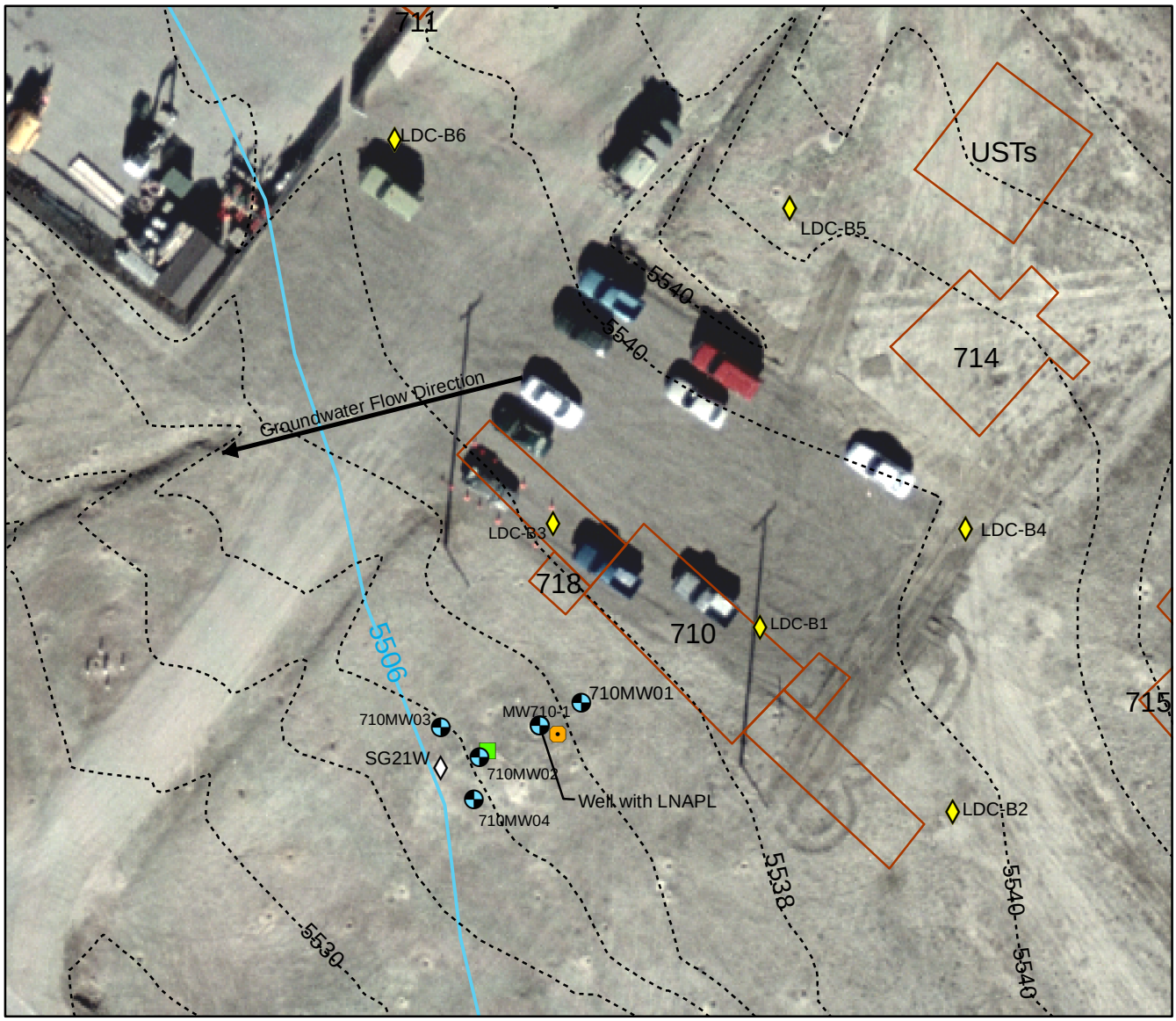

N

0 20 40

Feet

Legend

- Monitoring Well
- Shallow Temporary Well
- Temporary Well
- Former Structure
- Former Oil Water Separator
- Former Oil UST
- Potentiometric Contour for Deep Zone (June 2006)
- Topographic Contour

Figure 1
LNAPL Area
Well Locations
Buckley Air Force Base

q:\Gis\Buckley\Lnapl2-Well-location.mxd 9/17/07

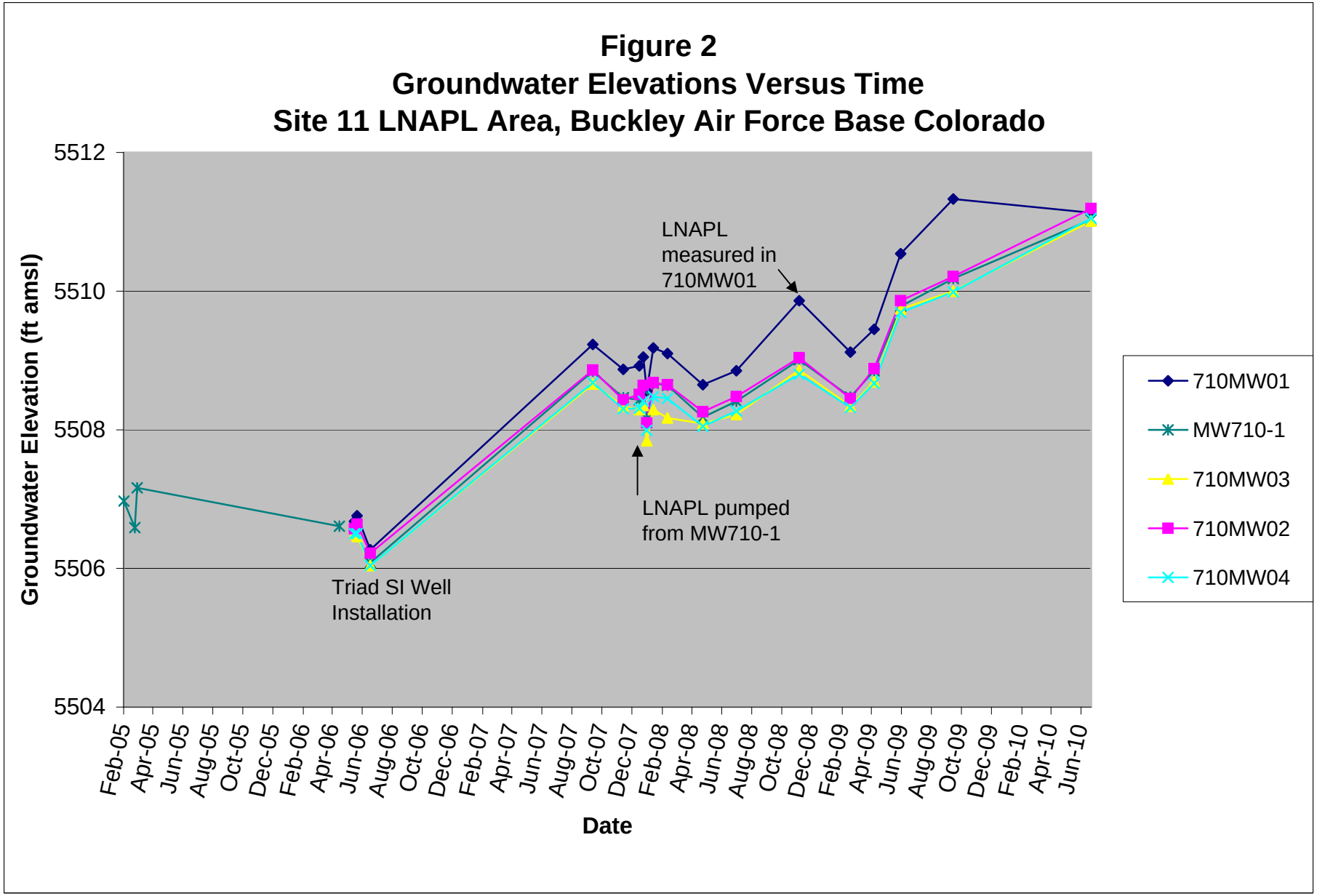
Figure 2
Groundwater Elevations Versus Time
Site 11 LNAPL Area, Buckley Air Force Base Colorado
Groundwater Elevation (ft amsl)
5512
5510
5508
5506
5504
LNAPL measured in 710MW01
LNAPL pumped from MW710-1
Triad SI Well Installation
Feb-05
Apr-05
Jun-05
Aug-05
Oct-05
Dec-05
Feb-06
Apr-06
Jun-06
Aug-06
Oct-06
Dec-06
Feb-07
Apr-07
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Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09
Oct-09
Dec-09
Feb-10
Apr-10
Jun-10
Date
710MW01
MW710-1
710MW03
710MW02
710MW04

Table 1
Well MW710-1 Water-Level and Product Measurements
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Top of Screen (ft bgs)	Base of Screen (ft bgs)	Top Screen Elevation (ft amsl)	Base Screen Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)	Uncorrected Depth to Water from MP (feet)	Depth to Product from MP (feet)	Thickness of Product (feet)
MW710-1	2/17/92	2	5536.45	5538.09	30	45	5506.45	5491.45	1.64	44.63	2/17/1992	35[b]	5501.45[b]	NA	None	None
	(as MW-6)										2/20/1992	31.2[c]	5506.89[c]	NA	None	None
											12/2004[d]	NA	NA	NA	about 30.6	0.83[d]
											2/3/2005	31.12	5506.97	NA	None	None
											2/25/2005	31.5	5506.59	NA	Film	Film
											3/2/2005	30.93	5507.162	31.09	30.89	0.20
											4/17/2006	31.48	5506.61	33.10	31.10	2.00
											6/19/2006	32.01[e]	5506.08	NA[e]	NA[e]	NA[e]
											9/14/2007	29.25	5508.84	29.48	29.19	0.29
											11/15/2007	29.63	5508.46	29.86	29.58	0.28
											12/18/2007	29.66	5508.43	29.89	29.61	0.28
											12/26/2007	29.51	5508.58	NA[f]	None[f]	None[f]
											1/2/2008	29.93	5508.16	NA[f]	None[f]	None[f]
											1/15/2008	29.42	5508.67	NA[f]	None[f]	None[f]
											2/13/2008	29.45	5508.64	NA[f]	None[f]	None[f]
											4/25/2008	29.91	5508.18	NA[f]	None[f]	None[f]
											7/2/2008	29.68	5508.41	NA[f]	None[f]	None[f]
											11/7/2008	29.08	5509.01	NA[f]	None[f]	None[f]
											2/19/2008	29.62	5508.47	29.62	29.62	<0.01
											4/8/2009	29.24	5508.85	NA[f]	None[f]	None[f]
											6/1/2009	28.31	5509.78	NA[f]	None[f]	None[f]
											9/16/2009	27.91	5510.18	NA[f]	None[f]	None[f]
											6/23/2010	27.06	5511.03	NA[f]	None[f]	None[f]

[a]The corrected depth to water provided is the depth to water minus the product of the LNAPL thickness times its density (0.81).

[b]No datum was provided; it is assumed this measurement is the depth from ground surface (during well installation) for the water elevation calculation.

[c]No datum was provided; it is assumed this depth was measured from the MP (prior to sampling) for the water elevation calculation.

[d]The thickness of the product was measured, then the well was purged and sampled.

[e]No specific product measurements are available; however, the field geologist indicated a couple inches (e.g., about 0.2 foot) were present. It is assumed the water depth was corrected.

[f]After measurements on 12/18/2007, LNAPL and water were pumped from well and a sorbent sock was placed in well.

ft amsl - feet above mean sea level
ft bgs - feet below ground surface
MP - measuring point (top of polyvinyl chloride casing)
NA - not applicable or not available
< - less than

Historical Data Sources: 1992 data from ATEC, 1992
2004-2005 data provided by URS, with exception of 2/3/05 data collected by Versar for Site 3
2006 data from Final Triad Site Inspection Report for Building 1011 Area of Concern (Versar, 2007a)
Well elevation data from Versar surveys

Table 2
Historic and Current Water-Level Measurements
Site 11 LNAPL Area
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)
Temporary Wells									
LDC-B1	2/19/05	2	5539.80	5541.25	1.45	29.40	2/19/2005	18.95	5522.30
							2/25/2005	20.29	5520.96
							3/2/2005	20.34	5520.91
							3/21/2006	20.44	5520.81
							3/23/2006	20.54	5520.71
							4/17/2006	20.34	5520.91
							6/19/2006	20.61	5520.64
							12/18/2007[b]	19.11	5522.14
LDC-B2	2/19/05	1	5540.23	5540.78	0.55	30.10	2/19/2005	20.75	5520.03
							2/25/2005	20.81	5519.97
							3/2/2005	20.81	5519.97
							3/21/2006	20.63	5520.15
							3/23/2006	20.76	5520.02
							6/19/2006	20.88	5519.9
							12/18/2007[b]	19.29	5521.49
LDC-B3	2/19/05	1	5538.88	5538.56	-0.32	25.09	2/19/2005	24.36	5514.20
							2/25/2005	21.37	5517.19
							3/2/2005	20.97	5517.59
							3/23/2006	20.94	5517.62
							6/19/2006	19.95	5518.61
							12/18/2007	NF	NF
LDC-B4	2/19/05	1	5541.14	5541.87	0.73	30.10	2/19/2005	19.7	5522.17
							2/25/2005	19.76	5522.11
							3/2/2005	19.78	5522.09
							6/19/2006	20.04	5521.83
							12/18/2007[b]	NM	NM
LDC-B5	2/19/05	2	5543.14	5544.28	1.14	30.44	2/19/2005	21.86	5522.42
							2/25/2005	21.86	5522.42
							3/2/2005	21.87	5522.41
							6/19/2006	21.25	5523.03
							12/18/2007[b]	20.79	5523.49
LDC-B6	2/19/05	2	5539.25	5539.87	0.62	25.68	2/19/2005	18.42	5521.45
							2/25/2005	18.41	5521.46
							3/2/2005	18.43	5521.44
							6/19/2006	18.23	5521.64
							12/18/2007	NF	NF
SG21W	4/18/06	1	5533.57	5533.81	0.24	43.24	6/19/2006	27.75	5506.06
							9/14/2007	25.10	5508.71
							11/15/2007	25.48	5508.33
							12/18/2007[b]	25.48	5508.33

Table 2
Historic and Current Water-Level Measurements
Site 11 LNAPL Area
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)
Permanent Wells									
MW710-1	2/17/92	2	5536.45	5538.09	1.64	44.63	2/17/1992	35[c]	5501.45[c]
(aka MW-6)							2/20/1992	31.2[d]	5506.89[d]
							12/2004[e]	NA	NA
							2/3/2005	31.12	5506.97
							2/25/2005	31.50	5506.59
							3/2/2005	30.93	5507.16
							4/17/2006	31.48	5506.61
							6/19/2006	32.01	5506.08
							9/14/2007	29.25	5508.84
							11/15/2007	29.63	5508.46
							12/18/2007[f]	29.66	5508.43
							12/26/2007	29.51	5508.58
							1/2/2008	29.93	5508.16
							1/15/2008	29.42	5508.67
							2/13/2008	29.45	5508.64
							4/25/2008	29.91	5508.18
							7/2/2008	29.68	5508.41
							11/7/2008	29.08	5509.01
							2/19/2009	29.62	5508.47
							4/8/2009	29.24	5508.85
							6/1/2009	28.31	5509.78
							9/16/2009	27.91	5510.18
							6/23/2010	27.06	5511.03
710MW01	4/27/06	2	5537.25	5540.07	2.82	44.6	5/18/2006	33.39	5506.68
							5/23/2006	33.31	5506.76
							6/19/2006	33.80	5506.27
							9/14/2007	30.84	5509.23
							11/15/2007	31.20	5508.87
							12/18/2007	31.15	5508.92
							12/26/2007	31.02	5509.05
							1/2/2008	31.51	5508.56
							1/15/2008	30.89	5509.18
							2/13/2008	30.97	5509.10
							4/25/2008	31.42	5508.65
							7/2/2008	31.22	5508.85
							11/7/2008	30.21	5509.86
							11/13/2008[g]	29.89	5510.18
							2/19/2009	30.95	5509.12
							4/8/2009	30.62	5509.45
							6/1/2009	29.53	5510.54
							9/16/2009	28.74	5511.33
							6/23/2010	28.94	5511.13

Table 2
Historic and Current Water-Level Measurements
Site 11 LNAPL Area
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)
710MW02	5/1/06	2	5534.38	5537.24	2.86	38.8	5/18/2006	30.67	5506.57
							5/23/2006	30.60	5506.64
							6/19/2006	31.02	5506.22
							9/14/2007	28.38	5508.86
							11/15/2007	28.81	5508.43
							12/18/2007	28.73	5508.51
							12/26/2007	28.60	5508.64
							1/2/2008	29.14	5508.10
							1/15/2008	28.56	5508.68
							2/13/2008	28.59	5508.65
							4/25/2008	28.98	5508.26
							7/2/2008	28.76	5508.48
							11/7/2008	28.20	5509.04
							2/19/2009	28.79	5508.45
							4/8/2009	28.36	5508.88
							6/1/2009	27.38	5509.86
							9/16/2009	27.03	5510.21
							6/23/2010	26.05	5511.19
710MW03	5/1/06	2	5534.07	5536.78	2.71	38.6	5/18/2006	30.28	5506.50
							5/23/2006	30.32	5506.46
							6/19/2006	30.74	5506.04
							6/30/2006	30.78	5506.00
							9/14/2007	28.12	5508.66
							11/15/2007	28.44	5508.34
							12/18/2007	28.49	5508.29
							12/26/2007	28.43	5508.35
							1/2/2008	28.94	5507.84
							1/15/2008	28.49	5508.29
							2/13/2008	28.61	5508.17
							4/25/2008	28.69	5508.09
							7/2/2008	28.56	5508.22
							11/7/2008	27.92	5508.86
							2/19/2009	28.44	5508.34
							4/8/2009	28.09	5508.69
							6/1/2009	27.04	5509.74
							9/16/2009	26.78	5510.00
							6/23/2010	25.77	5511.01

Table 2
Historic and Current Water-Level Measurements
Site 11 LNAPL Area
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)
710MW04	5/3/06	2	5533.87	5536.62	2.75	42.56	5/18/2006	30.12	5506.50
							5/23/2006	30.12	5506.50
							6/19/2006	30.58	5506.04
							6/30/2006	30.62	5506.00
							9/14/2007	27.94	5508.68
							11/15/2007	28.32	5508.30
							12/18/2007	28.31	5508.31
							12/26/2007	28.21	5508.41
							1/2/2008	28.63	5507.99
							1/15/2008	28.14	5508.48
							2/13/2008	28.17	5508.45
							4/25/2008	28.57	5508.05
							7/2/2008	28.35	5508.27
							11/7/2008	27.82	5508.80
							2/19/2009	28.30	5508.32
							4/8/2009	27.95	5508.67
							6/1/2009	26.93	5509.69
							9/16/2009	26.63	5509.99
							6/23/2010	25.57	5511.05

[a]For the wells with product (MW710-1, 710MW01), this is the corrected depth to water (refer to Tables 1 and 3 for product measurements).
[b]Temporary wells that could be located were abandoned on 12/18/2007
[c]No datum was provided; it is assumed this measurement is the depth from ground surface (during well installation) for the water elevation calculation.
[d]No datum was provided; it is assumed this depth was measured from the MP (prior to sampling) for the water elevation calculation.
[e]The thickness of the product was measured, then the well was purged and sampled.
[f]After measurements were taken on 12/18/2007, LNAPL and water were purged and a sorbent sock was placed in well.
[g]After measurements were taken on 11/13/2008, a sorbent sock was placed in well.

ft amsl - feet above mean sea level
MP - measuring point (top of polyvinyl chloride casing)
NA - not available
NF - not found
NM - not measured (probe did not fit down bent casing)

Historical Data Sources: 1992 data from ATEC, 1992
2004-2005 data provided by URS, with exception of 2/3/05 Versar data
2006 data from Final Triad Site Inspection Report for Building 1011 Area of Concern (Versar, 2007a)
Well elevation data from Versar surveys

Table 3
Well 710MW01 Water-Level and Product Measurements
Buckley Air Force Base, Colorado

Site ID	Date Installed	Well Casing Diameter (inch)	Ground Elevation (ft amsl)	MP Elevation (ft amsl)	Top of Screen (ft bgs)	Base of Screen (ft bgs)	Top Screen Elevation (ft amsl)	Base Screen Elevation (ft amsl)	Stick-up (feet)	Total Depth from MP (feet)	Date Measured	Depth to Water from MP[a] (feet)	Water Elevation (ft amsl)	Uncorrected Depth to Water from MP (feet)	Depth to Product from MP (feet)	Thickness of Product (feet)
710MW01	4/27/2006	2	5537.25	5540.07	32	42	5505.25	5495.25	2.82	44.60	5/18/2006	33.39	5506.68	NA	None	None
											5/23/2006	33.31	5506.76	NA	None	None
											6/19/2006	33.80	5506.27	NA	None	None
											9/14/2007	30.84	5509.23	NA	None	None
											11/15/2007	31.20	5508.87	NA	None	None
											12/18/2007	31.15	5508.92	NA	None	None
											12/26/2007	31.02	5509.05	NA	None	None
											1/2/2008	31.51	5508.56	NA	None	None
											1/15/2008	30.89	5509.18	NA	None	None
											2/13/2008	30.97	5509.10	NA	None	None
											4/25/2008	31.42	5508.65	NA	None	None
											7/2/2008	31.22	5508.85	NA	None	None
											11/7/2008	30.21	5509.86	30.23	30.21	0.02
											11/13/2008	29.89	5510.18	29.91	29.89	0.02
											2/19/2009	30.95	5509.12	30.96	30.95	0.01[b]
											4/8/2009	30.62	5509.45	NA	None	None
											6/1/2009	29.53	5510.54	NA	Film	Film
											9/16/2009	28.74	5511.33	NA	None	None
											6/23/2010	28.94	5511.13	NA	None	None

[a]The corrected depth to water provided is the depth to water minus the product of the LNAPL thickness times its density (0.81).
[b]After measurements on 11/13/2008, a sorbent sock was placed in well.

ft amsl - feet above mean sea level
ft bgs - feet below ground surface
MP - measuring point (top of polyvinyl chloride casing)

Historical Data Sources: 2006 data from Final Triad Site Inspection Report for Building 1011 Area of Concern (Versar, 2007a)
Well elevation data from Versar surveys

Table 4
Wells MW710-1 and 710MW01 LNAPL Removal Monitoring
Buckley Air Force Base, Colorado

Date Measured	Corrected Depth to Water from MP (feet)	MP Elevation (ft amsl)	Water Elevation (ft amsl)	Monitoring Interval (weeks)	Change in Water Level During Interval[a] (feet)	Approximate Length of Impacted Sock (inches)	Estimated Volume Absorbed During Interval[b] (gallons)
Well MW710-1							
12/18/2007	29.66	5538.09	5508.43	0[c]	NA	NA	NA
12/26/2007	29.51		5508.58	1	0.15	3 - 3.6[d]	0.02
1/2/2008	29.93		5508.16	1	-0.42	3 - 3.6[d]	Negligible
1/15/2008	29.42		5508.67	2	0.51	3 - 3.6[d]	Negligible
2/13/2008	29.45		5508.64	4	-0.03	3 - 3.6[d]	Negligible
4/25/2008	29.91		5508.18	10	-0.46	3 - 3.6[d]	Negligible
7/2/2008	29.68		5508.41	10	0.23	3 - 3.6[d]	Negligible
11/7/2008	29.08		5509.01	18	0.60	3 - 3.6[d]	Negligible
2/19/2009	29.62		5508.47	15	-0.54	3 - 3.6[d]	Negligible
4/8/2009	29.24		5508.85	7	0.38	3 - 3.6[d]	Negligible
6/1/2009	28.31		5509.78	8	0.93	3.6[d]	Negligible
9/16/2009	27.91		5510.18	15	0.40	3.6[d]	Negligible
6/23/2010	27.06		5511.03	40	0.85	NM	NM
Well 710MW01							
11/13/2008	29.89	5540.07	5510.18	0[e]	NA	NA	NA
2/19/2009	30.95		5509.12	14	-1.06	3.6[d]	0.02
4/8/2009	30.62		5509.45	7	0.33	4.2[d]	0.004
6/1/2009	29.53		5510.54	8	1.09	4.8[d]	0.004
9/16/2009	28.74		5511.33	15	0.79	5.4[b]	0.004
6/23/2010	28.94		5511.13	40	-0.20	NM	NM

[a]Positive numbers indicate a rise in water level, and negative numbers represent a drop in water level

[b]Estimated volume is based on the absorbency of sock (about 0.1 gallon) and the approximate length of impacted sock vs. total length (15 inches)

[c]After measurements on 12/18/2007, LNAPL was pumped from well MW710-1, and a sock was placed in this well

[d]A stringer of absorbed hydrocarbons extending along one side of the sock is not included

[e]LNAPL was first measured in well 710MW01 on 11/7/2008 (0.02 foot); after measurements on 11/13/2008, a sock was placed in this well

ft amsl - feet above mean sea level

MP - measuring point (top of polyvinyl chloride casing)

NA - not applicable

NM - not measured; but not significantly different from previous event

1204199

Thermo Fluids Inc.
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(800) 350-7565

INVOICE/Bill of Lading - C

PO # _____

Next Pickup w/C Days

Truck Gross Wt _____
Tare Wt _____
Truck Net Wt _____
Truck # Vot. 3

FED ID 59-3210374 US DOT # 641752

CUST LOC #

Cust/Gen Name	Transporter Name	Receiving Facility
Buckley AFB	358	358
Address site 11	Address	Address
City, St Zip Aurora, CO 80011	City, St Zip	City, St Zip
Phone 303 450 1942	Phone	Phone
EPA # (if required)	EPA # (if required)	EPA # (if required)

Billing Address (if Different) _____

Materials	Inventory/ Tank Size	QTY P/U	QTY DEL	U of M	Rate	Total
Used Oil Halogen results						
Field Screen Halogen Test (Type) 0-100	1. Hydrochlor					
Gas/Diesel/Unused Fuel (Circle)						
Non RCRA Waste Antifreeze (>RQ use shipping name #2 on reverse)						
AF Premix/Conc/Extended Life (Circle) (>RQ use shipping name #2 on reverse)			Auth. #			
Filters						
Specialty Filters (Approval for sulfides)						
Sludge/Absorbent/Dirt (Circle) Approval #						
Oil/Water Mixture Approval #	40					
Oil Water Separator/Sump (Circle) Approval #		(2 gallons gas, 38 gallons water)				
Catch Basin Approval #						
Service Fee						
Other Truck Time	3 hours					
Other						
Other						

SHIPPING NAME FOR OTHER: _____ TOTAL _____

GENERATOR SIGNED BELOW, Subject to terms and conditions as specified on reverse side of form.

Generator	Transporter	Receiver
Signature	Signature	Signature
Name X John T Morris	Name Tim Rosebrough	Name Tim Rosebrough
Date 12-18-07 18 Nov 07	Date 12-18-07 18 Nov 07	Date 12-18-07 18 Nov 07

REMIT TO: **THERMO FLUIDS INC.**
39354 TREASURY CENTER
CHICAGO, IL 60694-9300

METHOD OF PAYMENT:
CASH/CREDIT/
CHECK # _____

Sock from Well MW710-1 on December 26, 2007, 1 week after LNAPL pumped

Another view of sock from Well MW710-1 on December 26, 2007 – note linear hydrocarbon staining is not pervasive through sock

Sock from Well MW710-1 on January 2, 2008, 2 weeks after LNAPL pumped – appearance not significantly different from previous week

Sock from Well MW710-1 on January 15, 2008, 4 weeks after LNAPL pumped – appearance not significantly different from 2 weeks prior (measurements are in 0.1 foot)

Sock from Well MW710-1 on February 13, 2008, about 2 months (8 weeks) after LNAPL pumped – appearance not significantly different from 1 month prior (measurements are in 0.1 foot)

Sock from Well MW710-1 on July 2, 2008, about 7 months after LNAPL pumped – appearance on this side of sock not significantly different from prior events

Sock from Well MW710-1 on November 7, 2008, about 11 months after LNAPL pumped – appearance not significantly different from previous events

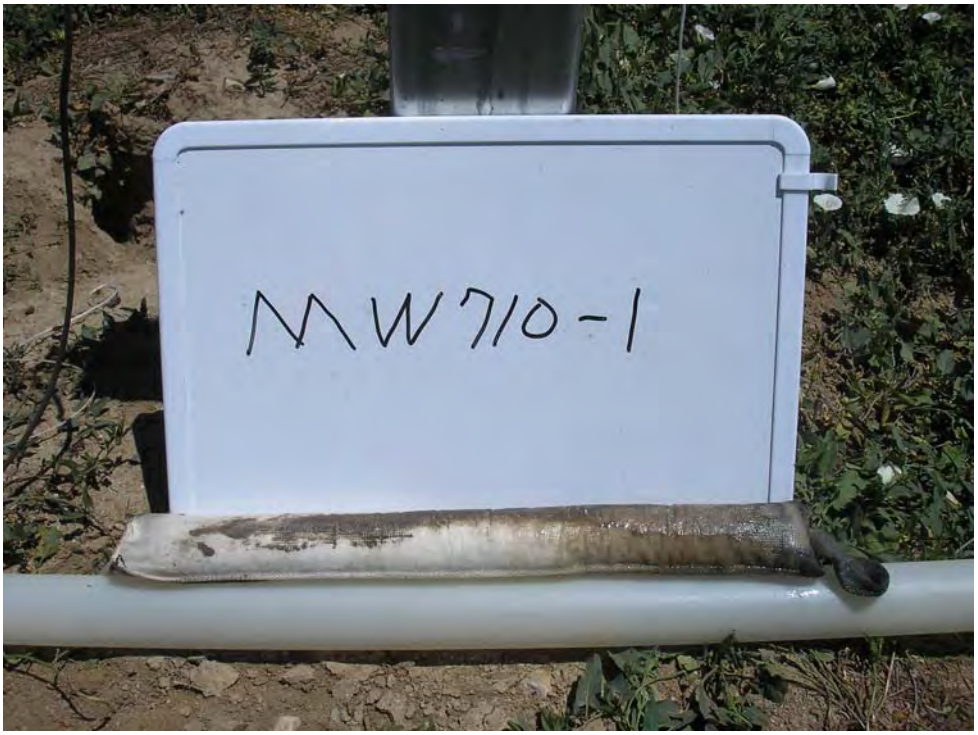
Other side of sock from Well MW710-1 on November 7, 2008, about 11 months after LNAPL pumped – appearance not significantly different from previous events

Sock from Well MW710-1 on February 19, 2009, 14 months after LNAPL pumped – appearance not significantly different from previous events

Other side of sock from Well MW710-1 on February 19, 2009, 14 months after LNAPL pumped – appearance not significantly different from previous events

Sock from Well 710MW01 on February 19, 2009, 3 months after placed in well

Other side of sock from Well 710MW01 on February 19, 2009,
3 months after placed in well



Sock from Well MW710-1 on June 23, 2010, 30 months after LNAPL pumped – appearance not significantly different from previous events

Sock from Well 710MW01 on June 23, 2010, 19 months after placed in well

Sock from Well MW710-1 on September 16, 2009, 21 months after LNAPL pumped – appearance not significantly different from previous events

Other side of sock from Well MW710-1 on September 16, 2009, 21 months after LNAPL pumped – appearance not significantly different from previous events

Sock from Well 710MW01 on September 16, 2009, 10 months after placed in well

Other side of sock from Well 710MW01 on September 16, 2009,
10 months after placed in well

Re DF 1 yr LNAPL Report EPA

From: <Rathke.David@epamail.epa.gov> [Rathke.David@epamail.epa.gov]
Sent: Thursday, April 16, 2009 3:23 PM
To: LAROCK, ED J
Cc: Roche, Donald; Mcintyre, Dana J Civ USAF AFCEE AFCEE/EXEC; Spangler, Mark; Pivonka, LEE J; nwireman@portageinc.com; Fernando, Joe; Hlavacek, Brian; Glenn, Nan
Subject: Re: DF 1 yr LNAPL Report

Nan - Ed and I have discussed this report and I concur with his suggestion.

dr

DAVID RATHKE
US EPA REGION 8, 8EPR-F
1595 WYNKOOP STREET
DENVER, CO 80202-1129

303 312-6016 Phone
303 312-7150 Fax

"ED J LAROCK"
<ejlarock@cdphe.
state.co.us>

04/16/2009 02:52
PM

To
"Nan Glenn" <NGlenn@Versar.com>
cc
"Donald Roche"
<droche@auroragov.org>, "Dana J
Civ USAF AFCEE AFCEE/EXEC
Mcintyre"
<dana.mcintyre@brooks.af.mil>,
"Mark Spangler"
<mark.spangler@buckley.af.mil>,
"LEE J Pivonka"
<ljpivonk@cdphe.state.co.us>,
David Rathke/EPR/R8/USEPA/US@EPA,
<nwireman@portageinc.com>, "Joe
Fernando"
<jfernando@prudentweb.com>,
"Brian Hlavacek"
<bhlavace@tchd.org>
Subject
Re: DF 1 yr LNAPL Report

Nan,

The report is fine; I agree that the final LNAPL report will be appended to the Site 11 RI report after the next two LNAPL monitoring events are complete. Rather than request closure for this portion of Site 11 at that time (if appropriate), it may be easier to request discontinuing the LNAPL Removal and Monitoring program for this area.

Re DF 1 yr LNAPL Report EPA

I agree that some of the wells in the LNAPL area could be useful for the groundwater RI portion of Site 11 and should not be abandoned until this decision is coordinated with the Technical Working Group.

Please copy Mr. Lee Pivonka of CDPHE on future submittals (lee.pivonka@state.co.us). His phone number is 303 692 3453.

If there are any question on this, please contact me.

thanks.

Ed LaRock
Hazardous Materials and Waste Management Division Colorado Dept. of Public Health and Environment 4300 Cherry Creek Drive South Denver, CO 80246-1530
303-692-3324
Fax 303-759-5355
ed.larock@state.co.us

>>> "Nan Glenn" <NGlenn@Versar.com> 4/8/2009 12:14 PM >>>
All,
Attached is the LNAPL report for your review. It has been updated from the version included in the Final EE/CA for Site 11 Soil and Petroleum LNAPL to include monitoring through February 2009. Thank you. Nan

APPENDIX C

SITE 11 RI FIELD FORMS

Versar INC.

Lithology Log

Sheet 1 of 2

LOCID
11MW01

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB - Site 11 RI	111715.0003	3/10/09 - 14:10	3/10/09 - 16:51

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	25.2'	25.2'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)	
Boart Longyear Lele	Hollow Stem Auger	7 1/4"	First 15.6' based on moisture content	Final 9.35 (Keck)

Type of Sampling Device	Sample Hammer	Checked by/Date
Split Spoon (2')	Type Safety Hammer Driving Wt. 140 lbs. Drop 30"	N Glenn 4/13/09

Location Description (include sketch in field logbook)

South corner of berm

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.2	6 6 7 7	0'-14': Clayey silt includes white $CaCO_3$ deposits, organic material on top (i.e. roots), 7.5YR 4/2 - brown, slight plas., stiff	ML	SLCL	D	—	5	95	PID screen: 0 PID head space: 0 (1')
2		1	6 6 8 9								
4		.7	9 9								
5			9 9								PID head space: 0 (5')
6			14 14	gravelly sand lens @ 6.5' (~2' lens)							
7			12	SAA							
8			13 17 20	gravelly sand lens @ 7.5' (~2' lens) 8' - getting moist			M				
9			19 19	SAA - increasing in clay content							
10			7 8 12 13								PID headspace: 0 (10')
12			16 17 17 18	SAA - appearance of gravel, increased sand content	ML		M	trace	15	85	
14			15 16	14'-15.6': Sandy, clayey silt 7.5YR 4/3 - brown, slight plas., stiff	ML	SCSD/ SLCL	M	trace	20	80	PID headspace: 0 (15')
15			4 5 5 6	15.6'-17': SAA, wetter, more gravel			W	2	20	78	
16			5 7 7	17'-17.8': clayey sand poorly sorted, loose	SC	SC	S	—	60	40	
17			21	17.8'-18.5': SA 14'-15.6', 7.5YR 4/3 clayey silt	ML	SDCL SLCL	M	trace	20	80	
18			5 15	18.5'-24': coarse sand qtz, fsp, dark minerals, well sorted, subrounded, 7.5YR 5/4 - brown, coarsens downward	SP	SD CR	S	2	95	3	PID headspace: 0 (20')
19											
20											

Versar INC.

Lithology Log (continued)

Sheet 2 of 2

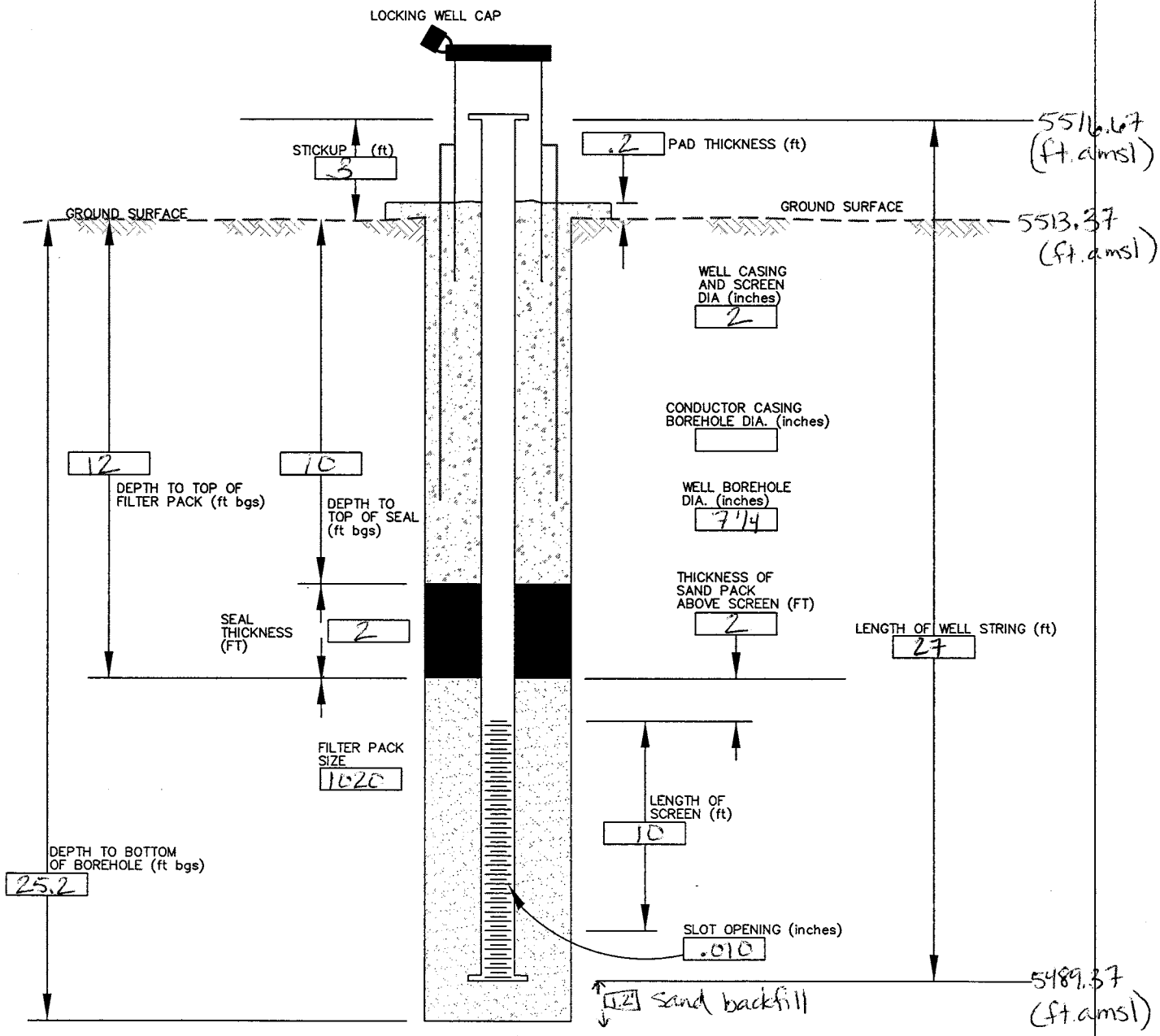
LOCID: 11MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20			5 7 14 13	SAA	SP						
22			5 10 18 50/5	SAA	SP						
24			50/2 32 50/5	24'-24.2': sandy silt 7.5YR 3/3 - dk. brown, med. plas, hard	~~CL~~ ML	SLSD					PID headspace: 0 (25')
26				24.2'-25.2': silty fine sand (Denver Formation?) (cemented in place), 10YR 4/6 - dk. yellowish brown, varies loose - dense	SM	SDFN	M	–	80	20	
28											
30											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW001	BAFB - Site 11 RI	111715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/10/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D Roth	N Glenn	4/13/09



COMMENTS:

filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

Versar INC.

Lithology Log

Sheet 1 of 1

LOCID	Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
11MW02	BAFB - Site 11 RI	11715.0003	3.10.09 / 10:00	3.10.09 / 11:45

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	17'	17'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs) First	Water Level (bgs) Final
Boart Longyear 66	Hollow Stem Auger	7 1/4"	est. 11'	12.5 bgs 12 bTOC (Keck)

Type of Sampling Device	Sample Hammer	Checked by/Date
5' continuous sampler & 2' split spoon	Type Safety Hammer Driving Wt. 140 lbs Drop 30"	N Glenn 4/13/09

Location Description (include sketch in field logbook)

Perimeter road, near south end of 'berm', North of 11MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0				0'-1.3': sand w/gravel, clay silt contains road fragments, poorly sorted, subrounded, 7.5YR4/1 - dark grey, loose	SM	SDGR/SDSL/SDCL	M	5	60	35	PID screen: 0
2		34"		1.3'-3.3': clayey silt becoming more clayey, mod. sorted, 10YR4/3 - brown, med. plas, v. stiff	ML ~~CL~~	SLCL	M	—	5	95	
4											
5				5'-5.7': SAA (low recovery due to loose sand, or something stuck in sampler	ML ~~CL~~		M	—	5	95	PID head space: 0 (3'4")
6											
8											
10 (cont. sampler)			4 4 9 18	10'-11': clayey silt 7.5YR4/2 - brown	ML ~~CL~~		M	—	trace	100	PID screen: 0-1.7
12 (split spoon)			21 26 37	11'-11.4': med-fine grain sand wet zone @ 11', 7.5YR4/4, mod. dense	SP	SDMD/SDFN	W	trace	100	—	PID screen: 0-2
13.5			45 46 48	11.4'-13.5': silty sand weathered, muscovite flecks, mod-well sorted, 7.5YR4/4 - brown, mod. dense	SP-SM	SDSL	M	—	90	10	PID head space: 0 (13.5') PID screen: 0
14											
15			18 26 36 50/5	13.5'-14.5': SAA	SP SM		W	—	90	10	
16				14.5'-15': siltstone (Denver formation?) well sorted, subrounded, 2.5 YR 5/3 - lt. olive brown, hard	~~CL~~ ML	SLST	M	—	—	100	PID head space: ~~0~~ 2 (15')
17				15'-17': SAA							
18											
20											

SAA - same as above

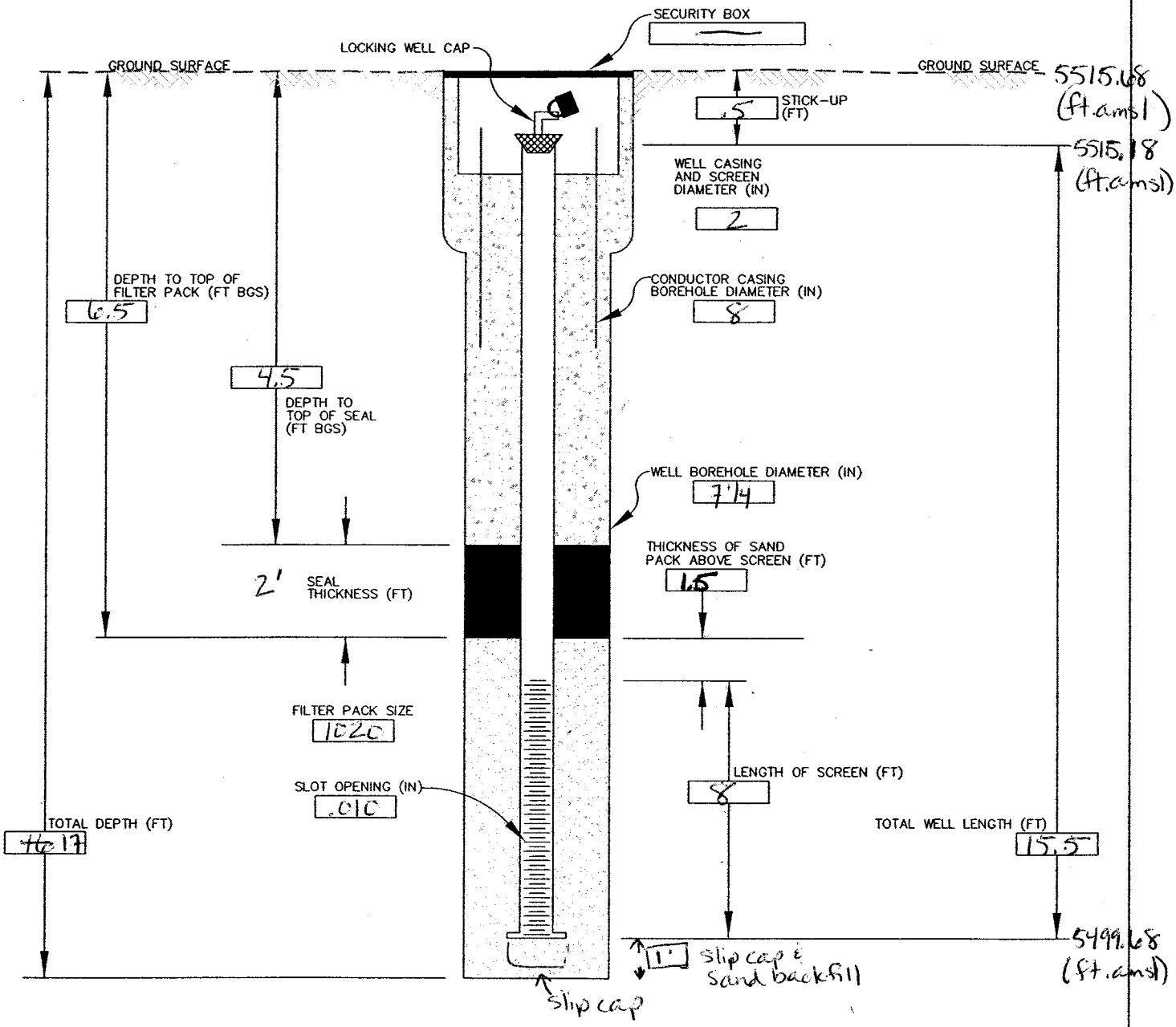
med. - medium mod - moderately

lt. - light plas - plasticity

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Flush–Mount

Location ID:	Project Name:	Project #:
11MW02	BAFB- Site 11 RI	111715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/10/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



COMMENTS: Sampled to 17' w/split spoon

filename: FIELD-FORMS-WELL\WELCONS4-032906.dwg PLOTTED: 3/29/06

Versar INC.

Lithology Log

Sheet 1 of 3

LOCID
11MW03

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB-Site 11 RI	111715.0003	3/11/09 : 09:30	3/11/09 - 1415

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	55'	55'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)
Boart Longyear 66	Hollow Stem Auger	7 1/4"	First 49.5' (Keck) - after well completion ~~Final~~ 3/11/09 - 1550

Type of Sampling Device	Sample Hammer	Checked by/Date
Split Spoon, Continuous Sampler (5')	Type Safety Hammer, Driving Wt. 140 lbs, Drop 30"	N Olean 4/13/09

Location Description (include sketch in field logbook)

North end of perimeter road

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.4	9 6 6 9	0'-6': Sandy silt w/asphalt chunks, road base, grades into next layer 10YR2/2 - v. dark brown, slight plas, soft	ML	SCSD	D	5	35	60	
2		1.2	11 14 21 33	6'-4.8': clayey silt contains white CaCO3 deposits some iron staining, sand quantities vary (3% max), 10YR4/6 - dk yellowish brown, slight plas, firm	ML	SCCL	D	–	3	97	
4			33 48								
5	split spoon → cont. sampler		23 50/5	4.8'-16': silty sand fine sand, grades downward to med. sand, traces of gravel & coarse sand found @ 7' & deeper, mod-well sorted, sub-angular, 7.5YR4/6 - strong brown, loose	SM	SOSL	D	–	60	40	PID head space: 0 (5')
6			46 50/4					trace			
7											
8				low recovery due to sands							
10		1.5		still grading downward (30% coarse sand)							PID head space: 0 (8')
12		1		SAA							
14											
15				15'-16': finer grains than previous, no coarse sand							PID head space: 0 (13')
16		2.7		16'-20.5': clayey silt - Denver Formation? 10YR4/4 - dk. yellowish brown, med. plas, stiff	~~CL~~ ML	SCCL	D-M	–	–	100	
18											
20											PID head space: 0 (17.7')

Versar INC.

Lithology Log (continued) Sheet 2 of 3

LOCID: 11MW03

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20				SAA							
		22									
22											
24											
25				trace of fine sand towards 25'				—	trace	100	PID head space: 0 (22.2')
26											
		35		26.5'-27.5': clayey siltstone weathered bedrock, traces of fine sand, 10YR 5/4 - yellowish brown, high plas, hard	ML	SLCY	D	—	trace	100	
28				27.5'-31.4': silty sand fine sand, has some hard pieces, well sorted, 10YR 4/4 - dk. yellowish brown, loose	SM	SDSL	D-M	—	60	40	PID head space: 0 (29')
30				31.4'-33.2': clayey silt 7.5YR 4/3 - brown, slight plas, stiff	ML	SLCL	D-M	—	trace	100	
32				33.2'-35.6': clayey silt 10YR 4/1 - dk grey, med plas, v. stiff, blocky (chocolate chunks)	~~CL~~ ML	SLCL	D-M	—	—	100	
34											
35		19		35.6'-36.2': clayey sand fine sand, well sorted, 7.5YR 4/4 - brown, loose	SP-SC	SDCL	M	—	60	40	PID head space: 0 (34')
36				36.2'-37.2': clayey silt 10YR 5/2 - greyish brown, med. plas, stiff - v. stiff, blocky	~~CL~~ ML	SLCL	D-M	—	—	100	
38				37.2'-55: Denver Blue claystone 60% clay, 40% silt, 6GEY2-5/5B - blueish grey, med. plas., hard	~~MH~~ CL	CLST	D	—	—	100	PID head space: 0 (37')
40											
42											
44											
45				more clayey towards 45'							PID head space: 0 (44')
46											

Versar INC.

Lithology Log (continued)

Sheet 3 of 3

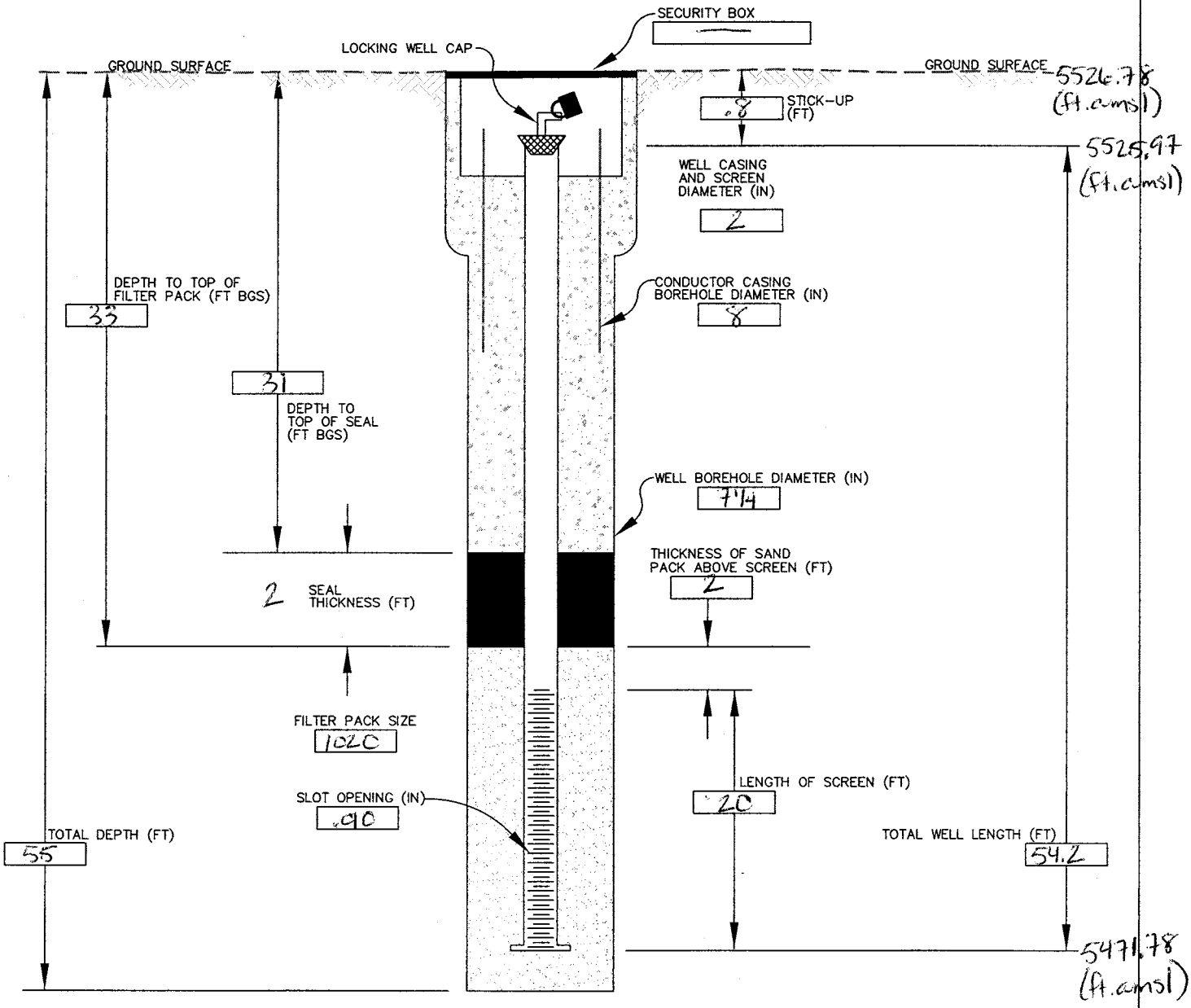
LOCID MW03

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
46				SAA	~~HE~~		D	—	—	100	
		43		color changes from 7.5YR4/1-dk. gray to 5GY2-4/10B-dk. bluish gray @ 47.5'	CL						
48											
50				SAA							PID head space: 0 (49.3')
52											
54											
55											PID head space: 0 (54')
56											
58											
60											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Flush–Mount

Location ID:	Project Name:	Project #:
11MW03	BAFB Site 11 RI	111715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/11/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



COMMENTS:

filename: FIELD-FORMS-WELL\WELCONS4-032906.dwg PLOTTED: 3/29/06

Versar INC.

Lithology Log

Sheet 1 of 2

LOCID	Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
IMW04	BAFB Site 11 - RI	111715.0003	3/13/09 - 0930	3/13/09 - 1240

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	35'	35'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)	
Boart Longyear 60	Hollow Stem Auger	7 1/4"	First no water	Final 34.75 (during well development) (KEC)

Type of Sampling Device	Sample Hammer	Checked by/Date
Split Spoon (2') continuous sampler (5')	Type Safety Hammer; Driving Wt. 140 lbs; Drop 30"	N Glenn 4/13/09

Location Description (include sketch in field logbook)

west end of parking lot, near UST & old steam line

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0				0'-6.4': FILL							
			6 8 9 8	0'-1': silty sand med. sand, bits of gravel, poorly sorted, grades from 10YR2/1-black → 10YR5/6-yellowish brown, poorly sorted, loose, asphalt chunks	SW	SDSL	D	10	85	5	PID screen: 2 (on asphalt)
2		1.5	5 7 10 11	1'-2': fine-med sand some silt, white $CaCO_3$ deposits, well sorted, 10YR6/6-brownish yellow, loose	SP	SDFN/ SDMD	D-M	—	95	5	
4			5 8	2'-6': clayey, sandy silt some fine sand, 40% med-coarse sand @ 4-4.5' then back to clayey silt (now w/30% fine-med. sand), white $CaCO_3$ deposits, well-v. well sorted, 10YR5/6 yellowish brown, loose	ML	SCL/ SCSD	D-M	—	5	95	PID head space: 0 (5')
5		1.7	8 10 10								
6			12 7 7 16 15	6-6.4': gravelly sand asphalt w/slight petroleum odor (PID screen: 2), poorly sorted, 10YR2/1-black	SW	SDGR	D	10	90	trace	
7											
8		1.8									
9			15 14	6.4-~~7.4~~ 15': layers (thin) of ~~sand~~ med. sand & silty clay	SP/ ~~MH~~ CL	SDMD & CLSL					
10			5 7 9 12	6.4'-7.4': med sand traces of coarse, 10YR5/6-yellowish brown, v. well sorted, loose	SP		D	—	100	—	PID head space: 0 (10')
				7.4-8.4': silty clay, 40% silt, 60% clay, 10YR4/6-dk yellowish brown, high plas., stiff	~~MH~~ CL		D-M	—	—	100	
				8.4'-10': same as 6.4-7.4							
12		1.5	12 14 12 14	10'-12': layers ~~as~~ thin to ~2' each, some iron staining in clay layers							
				12'-~~13.8~~ 13.8': med-coarse sand some iron staining, coarse w/ traces of gravel @ 13' (~2'), well sorted, 7.5YR5/6-strong brown, loose,	SP	SDMD SDGR	D	trace	100	—	
14			14 20	~~14-15': med sand~~							
15			21 33 40 8/6	13.8': silty clay, trace gravel chunks & iron staining, 7.5YR4/2-brown, med. plas, v. stiff	~~ML~~ CL		D	trace	—	100	
16				14'-15': med. sand	SP						
17		1.7		15'-17': clayey silt - start of DF? Significant iron staining along fractures, slightly fractured, blocky, 10YR5/6-yellowish brown, high plas, hard, also v. dark brown staining (7.5YR5/2), some fine sand	~~CL~~ ML	SCL	D	—	3	97	
18											
20				17'-20': clayey silt, no iron staining med-high plas, v. stiff, 10YR4/3 brown, (milk chocolate chunks), some fine sand	~~CL~~ ML		D	—	3	97	

Split Spoon

Cont Sampler

Versar INC.

Lithology Log (continued) Sheet 2 of 2

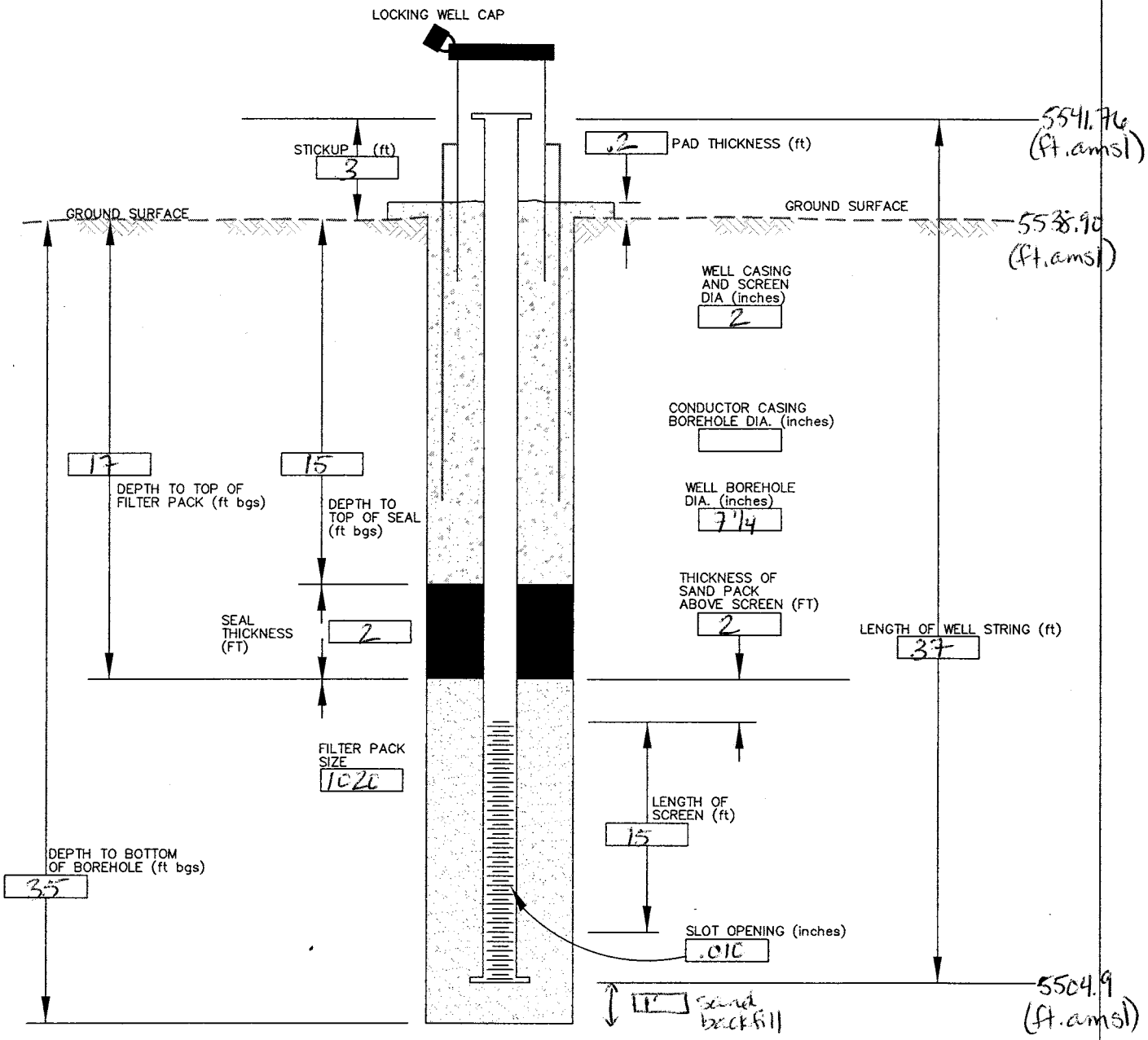
LOCID: 11MW04

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20				20'-30': clayey silt, clay content varies, traces of sand, layers of color variations (10YR5/4 - yellowish brown → 10YR5/6 - yellowish brown), blocky, very crumbled, seems highly weathered, slight plas., firm, (10YR5/6 starts @ 22.3' has ~3% fine sand)	~~CE~~ ML	SOCL	D	–	trace to 3	97-100	
22		34									
24											
25				SAM - some iron staining, some muscovite flecks, harder more siltstone chunks, 10YR5/4 - yellowish brown (for the most part)							PID head space: 0 (23.4')
26											
27											
28											
30				30'-34': silty, clayey sand fine-med sand, well sorted, 10YR5/8 - yellowish brown, loose	SP	SOSU SOCL	D-M	–	<90	10	PID head space: 0 (27')
32											
34				34'-35': Dark Blue, sandy silt 6LEY2 - 3/5PB	ML	SESD	D	–	trace	100	PID head space: 0 (34')
35											
36											
38											
40											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW04	BAFB, Site 11-RI	11715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/13/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



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Lithology Log

Sheet 1 of 3

LOCID
11MW05

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB - Site 11, RI	111715.0003	3/17/09 - 0900	3/17/09 - 1200

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	55'	55'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)
Beaut Longyear 66	Hollow Stem Auger	7 1/4"	First 26.93' (Reck) - after well completion; ~~Final~~ 3/17/09 - 15:00

Type of Sampling Device	Sample Hammer	Checked by/Date
Split Spoon (2'), Continuous Sampler (5')	Type: Safety Hammer; Driving Wt.: 140 lbs.; Drop: 30"	NGlem 4/13/09

Location Description (include sketch in field logbook)

SE end of parking lot, near LNAPL wells

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0	Split Spoon	1	6 8 11 12	0'-3.2': Sandy Silt contains organic material (i.e. roots), some asphalt debris near surface, 10YR5/4-yellowish brown, slight plas., v. stiff	ML	SLSD	D	trace	15	85	
2		1.0	12 17 25 35	3.2'-~~13~~ 10': Silt iron staining along fractures, white $CaCO_3$ deposits, blocky, 7.5YR5/3-brown, med. plas, v. stiff	ML	SILT	D	—	—	100	
4		.8	25 45								
5											PID head space: 0 (4.8')
6	Cont. Sampler	2.0									
8				9'-SAA, ↑ clay content, still iron staining, 10YR5/4-yellowish brown							
10		1.6									PID head space: 0 (7.3')
12				(too hard for split spoon, too soft/loose for continuous, ∴ low recovery)							
14				~~13'-15'~~ 10.6'-11.6': Silty Sand fine-med sand, muscovite flecks, traces of coarse ~~sand~~ gravel, well sorted, 10YR5/3-yellowish brown	SM	SDSL	D	trace	60	40	
15				15'-20': Clayey Silt; bedrock? blocky, 7.5YR4/3-brown, slight plas., soft	ML	SICL	D-M	—	trace (fine)	100	PID head space: 0 (11.6')
16		2.7		16'-change to 2.5Y6/1-gray, dry, contains some solid pieces, iron staining on fractures, otherwise SAA			D	—	trace (fine)	100	
18											
20											PID head space: ~~0~~ 1.3 (17.7')

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Lithology Log (continued)

Sheet 2 of 3

LOCID: 11MW05

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		23		20'-21': Sandy, clayey silt crumbly, 10YR5/6 - yellowish brown, slight plas. v.stiff	ML	SLSD/SLCL	D	—	40	60	
22				21'-26.7': clayey silt iron staining, crumbly, 10YR4/4 - dark yellowish brown, slight plas, v.stiff	ML	SLCL	D	—	trace	100	
24											
25		2		25'-SAA, 10YR3/4 - dk. yellowish brown							PID head space: 1.3 (22.3')
26				26.7'-~30': Sandy, clayey silt crumbly, 2.5Y6/4 - light yellowish brown, slight plas., soft	ML	SLSD/SLCL	D	—	20	80	
28											
30				not sure exactly where this switch is ~30'-31': ~~Clayey~~ silt (SA 21'-26.7') ~~w/more sand~~	ML	SLCL	D	~~VA~~ 0	~~VA~~ trace	~~100~~ 100	PID head space: .7 (27')
32		32		31'-33': Sandy silt 10YR4/4 - dark yellowish brown, slight plas., soft, loose	ML	SLSD	D	—	40	60	
34				33'-35': Silty sand fine-med sand, v.well sorted, 7.5YR4/6 - strong brown, loose	SM	SDSL	D-M	—	80	20	
35				35'-52': Sand (some silt) fine-med sand, well sorted, traces of coarse towards 39' (intermittent layers of coarse qtz: 39'-20% coarse, ~.2' thick), trace-5% coarse in between "coarse" layers, 7.5YR5/3 - dk. brown, loose-dense (dense in spots)	SP-SM	SDFN/SDMD	W-S	—	85-95	5-15	PID head space: 0 (33.2')
36		35									
38											
40											PID head space: 0 (38.5')
42											
44				44'-SAA, 10YR3/1 - v.dark gray; only traces of coarse sand							
45		18									PID head space: 0 (45')
46											

SA - Same as

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Lithology Log (continued)

Sheet 3 of 3

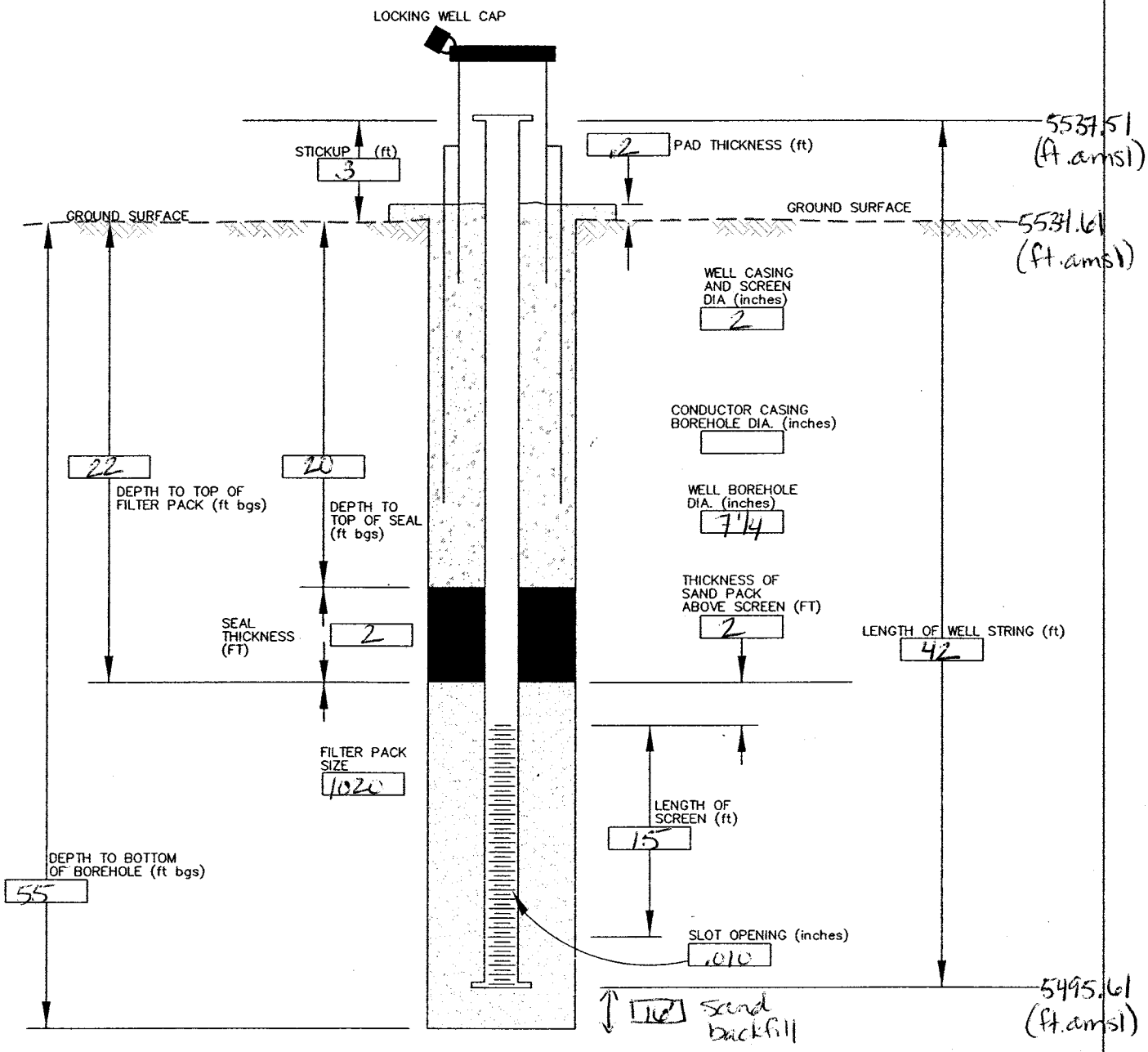
LOCID 11MW05

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
46				SAA - 10YR3/1 - v. dark gray			W-S				
48											
50											PID head space: 0 (46.3')
52				52'-55': Denver Blue - silty clay GREY 1-3/N - very dark gray, slight plas, stiff	CL	CLSL	M	—	—	100	
54											
55											
56											
58											
60											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 11MW05	Project Name: BAFB, Site 11-RI	Project #: 111715.0003
Construction Date: 3/17/09	Drilling Method: Hollow Stem Auger	Casing/Screen Material: PVC
Geologist: D. Roth	Checked By: N. Glenn	Date: 4/13/09



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Lithology Log

Sheet 1 of 2

LOCID: 11MW06			
Project Name: BAFB Site 11 - RI	Project Number: 1117715.0003	Date/Time Drilling Started: 3/12/09 - 0900	Date/Time Total Depth Reached: 3/12/09 - 1230
Drilling Company: Dakota Drilling	Driller: Gaige Kessel	Hydrogeologist: Deborah Roth	Total Depth Drilled: 40' / Total Depth Logged: 40'
Drilling Equipment: Bart Longyear 66	Drilling Method: Hollow Stem Auger	Borehole Diameter: 7 1/4"	Water Level (bgs): First 21.7' (Reck) after well completion ~~Final~~ 3/12/09 - 15:20
Type of Sampling Device: Split Spoon (2') Continuous Sampler (5')		Sample Hammer: Type Safety Hammer; Driving Wt. 140 lbs.; Drop 30"	Checked by/Date: N Glenn 4/13/09

Location Description (include sketch in field logbook): Crossgradient well to NE

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0			9 11 11 10	0'-5': Sandy silt contains angular gravelly chunks in various sections, contains clay, mixture of all shapes & sizes, looks like fill material, white CaCO3 deposits, poorly sorted, 7.5YR 5/4 - brown, dense	ML	SLSD	D	trace	3-15	85-97	
2		15	10 26 13 20								
4			27 19								
5			10 8 11 12	5'-21': Clayey silt varying quantities of sand (49% max), small white CaCO3 deposits, 7.5YR 4/4 - brown, well sorted, slight plas, stiff	ML	SLCL	D	—	trace	100	PID head space: 0 (5')
6											
7		15	8 6 6 5								
8											
9		15	5 5								
10			4 3 5 6								PID head space: 0 (9.5')
12		13	6 6 9 9								
14		17	9 8								
15			3 4 4 5	15: SAA - now D-M			D-M				PID head space: 0 (14.7')
16											
17		13	4 4 5 5	17: SAA - traces of coarse sand, some iron staining, now M			M				
18											
19			9 8	19': SAA - varies up to 25% sand							
20											PID head space: 0 (20')

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Lithology Log (continued) Sheet 2 of 2

LOCID: 11MW06

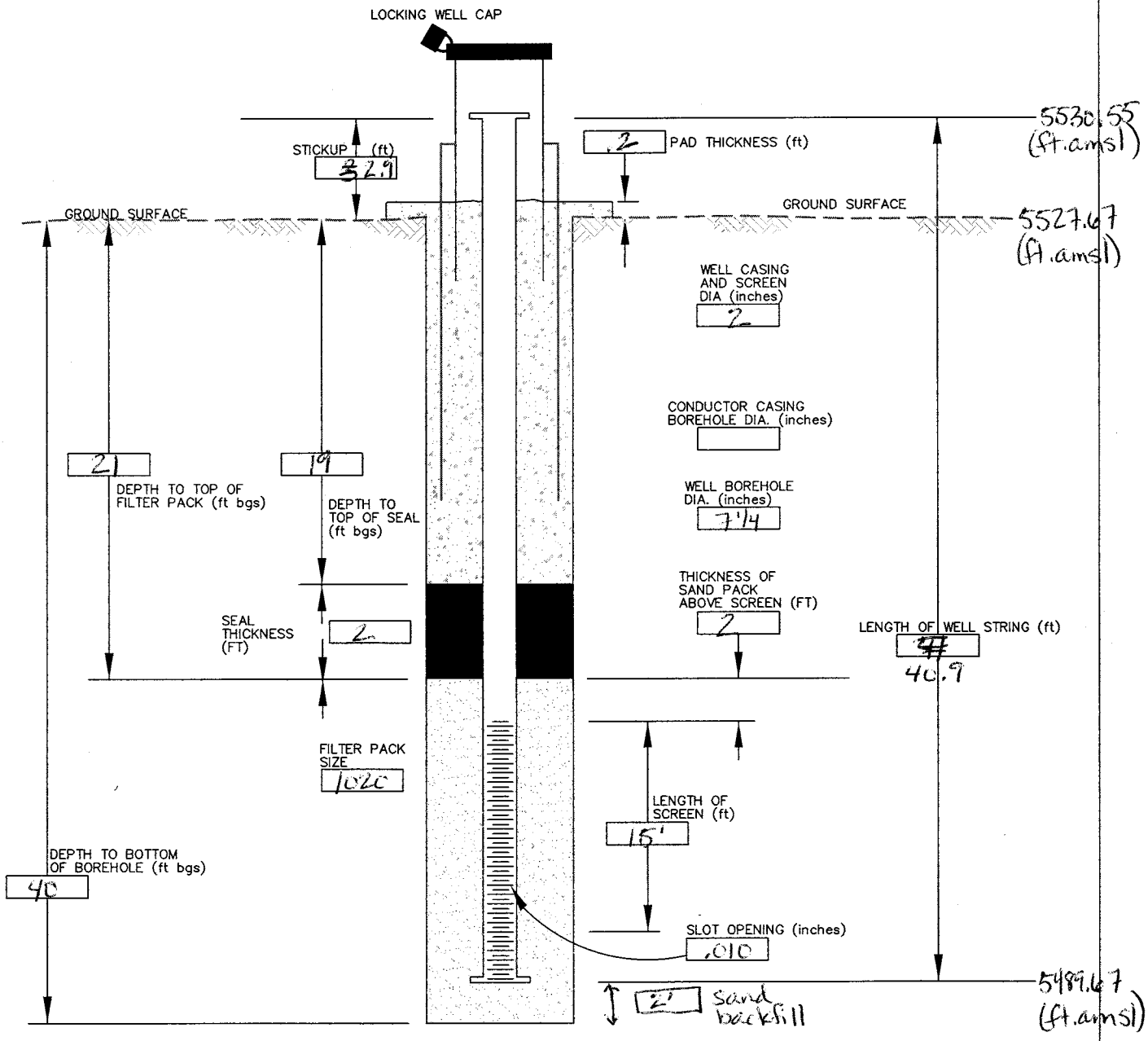
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		1.6	3 7 11 12	20'-21': SAM, up to 40% sand	ML		M	trace	40	60	
22			11 15 23 29	21'-23.5': silty clay - top of DF? highly weathered, fractured zones, iron deposits in fractures, sm. layer of fine sand (1"), black organic deposits, 7.5YR 4/3 brown, slight plas, v. stiff	CL	CLSL	D-M	—	—	100	
24			32 46	23.5'-25': sandy silt well sorted, slight plas, stiff, 10YR 4/6 dk. yellowish brown	ML	SLSD	D-M	—	40	60	PID head space: 0 (25')
25			48								
26			50/3 50/4	25'-38': med-fine grained sand med. to coarse sand: 26'-26.5' (saturated) well-v. well sorted, 7.5YR 3/3, dk. brown, loose	SM	SDFM SDMD	W	—	80	20	
27			50/5	27'-28' - med-coarse grain, wet-sat							
28			50/5								
29			50/5								
30		2.5		SAM - laminated color change, loose → hard in place							
32											
34											
35											
36				sand broken on top ∴ recovery assumed to be middle section							
37											
38				38'-40' Denver Blue assumed to start sandy silt well-v. well sorted, GLEY2-4/10B dark bluish gray, med plas., v. stiff, loose-dense	ML	SLSD	D	—	40	60	
40											
42											
44											
46											

Split spoon ↑ ↓ Cont. sampler

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW06	BAFB, Site 11 - RI	117715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/12/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



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Lithology Log

Sheet 1 of 2

LOCID	
11MW07	

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB Site 11 - RI	111715.0003	3/16/09 - 0920	3/16/09 - 1150

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	33'	33'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)	
Boart Longyear 66	Hollow Stem Auger	7 1/4"	First ~~S~~ 13.92 (Keck)	~~Final~~ after well completion 3/16/09 - 13:20

Type of Sampling Device	Sample Hammer				Checked by/Date
Split spoon (2')	Type: Safety Hammer	Driving Wt.: 140 lbs	Drop: 30"		N Glenn 4/13/09

Location Description (include sketch in field logbook)

along fence on SE end of Aspen Way, near Leach field

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.5	11 11 12 15	0'-11': Sandy silt fill material? some trace gravel & asphalt near surface, white $CaCO_3$ deposits, muscovite flecks, gravel disappears w/depth, fine sand increases w/depth (up to 5%); 10YR4/3-brown, slight plas, firm (consistency varies w/depth)	~~CL~~ ML	SLSD	D	trace	3-5	95-97	
2			19 21 23 10								
4		1.4	11 13								
5		1.8	8 8 8 7	SAA - 10% fine sand			D	—	10	90	PID head space: 0 (4.4')
7		1.2	6 7 7 9								
9		1.7	5 3	SAA - traces of med-coarse sand, addition of clay (~10%)			D-M	—	10	90	PID head space: 0 (9.7')
10		1.5	3 4 5 3	11'-13': ~~clayey silt~~ fine sand (3%), 10YR4/3-brown, slight plas, soft	ML	SLCL	D-M	—	trace 3	97-100	
12		1.3	3 4 5 6	13'-14.5': silty clay 10YR3/2-very dark grayish brown, slight plas, soft	~~ML~~ CL	CLSL	M	—	trace	100	
14			6 7	14.5'-22': clayey silt-silty clay 5% fine sand, traces of med sand, white $CaCO_3$ deposits towards 17', passes 'worm test' for clay, 10YR4/3-brown, varies to 10YR3/2 as above, slight plas, soft	ML/CL	SICL CLSL	M	—	5	95	PID head space: 0 (15')
15		1.8	1 2				W (@16')		3	97	
16			4 5								
17		1.5	3 5 7 9	SAA, but wet, less sand (3%)							
18											
19			6 9	more $CaCO_3$ deposits (4" layer @ 19' & 2" layer @ 20') sections w/ $CaCO_3$ have 5% sand							PID head space: 0 (20')
20											

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Lithology Log (continued) Sheet 2 of 2

LOCID: 11MW07

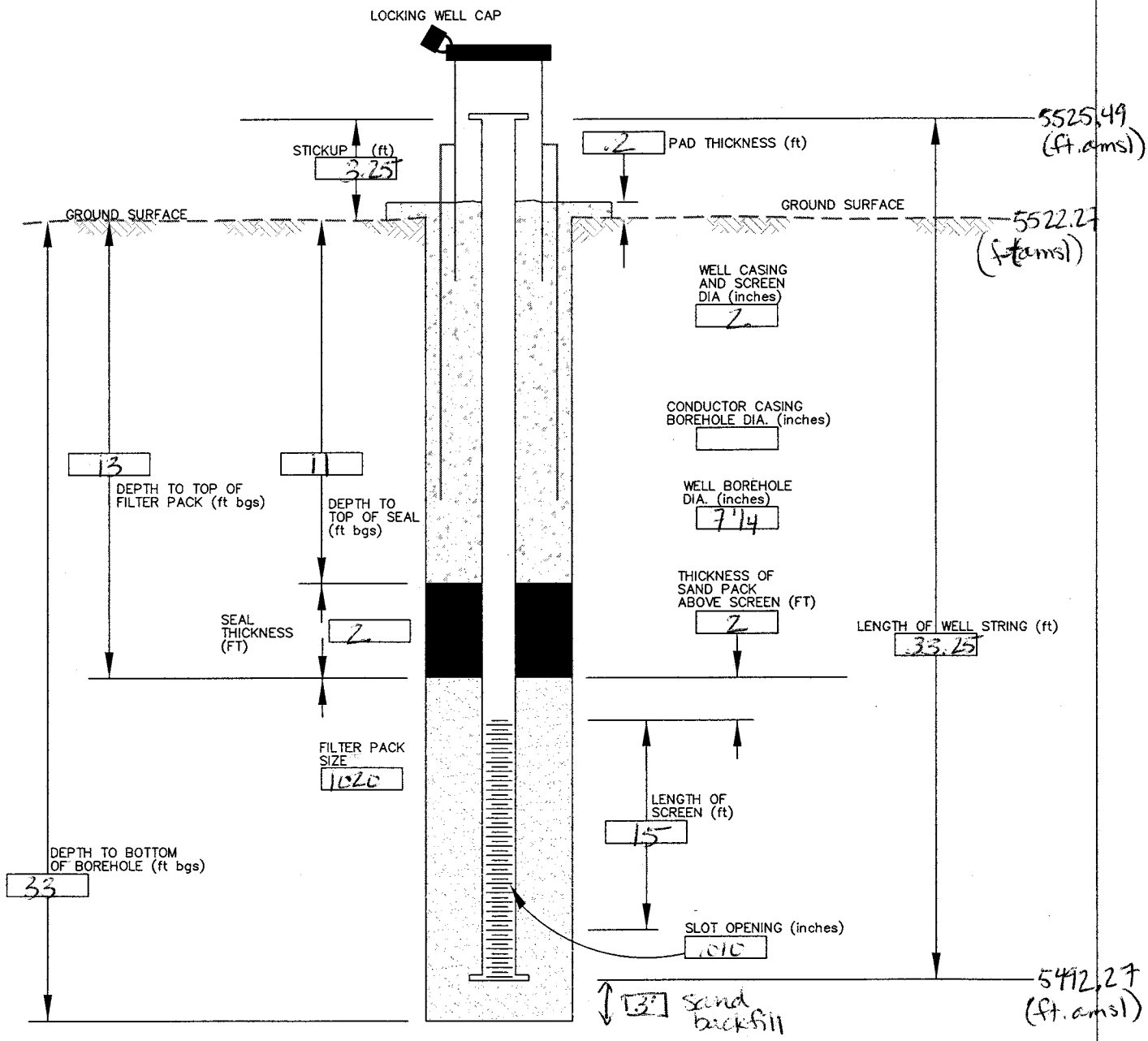
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		1.5	2 5 5 7	SAA 21' - SAA, 10YR5/4 - yellowish brown			M				
22			2 4 5 6	22'-25': Silty Sand, mostly med. med-fine sand, traces of coarse, mod-well sorted, 10YR5/4 - yellowish brown, loose	SM	SDSL	W-S	—	80	20	
24			4 7	25'-24': Clayey Silt contains ~1" layers of 15% fine-med sand, 10YR5/4 - yellowish brown, slight plas., soft	ML	SCL	W-S	—	15	85	PID head space: 0 (25')
25		1.7	4 6 5 6	24'-28.6': layers of silty sand & clayey silt as described above, layers 2"-5" thick, now saturated ~50% qtz, ~30% fsp, ~20% other	SM / ML		S	—	15/80	20/85	
26			3 10 20 32	28.6'-29': Clayey Silt (start of DF?) fractured, iron staining, 10YR4/1 - dark gray, mid plas, very stiff	ML	SCL	D-M	—	—	100	
27			35 50/6	29'-30': Silty Sand fine-med-coarse sand + gravel, poorly sorted, 10YR4/3 - brown, loose	SW-SM	SDSL	W	5	85	10	PID head space: 0 (30')
28			27 35 50/6	30'-33': Clayey Silt fractured, iron staining, varies 2.5Y5/3 - light olive brown → 2.5Y3/3 - dark olive brown, also 10YR4/1 - dark gray, mid plas, v. stiff	ML	SCL	M	—	—	100	
29			25 50/6				M-W (min. 32')				
30											
32											
33											
34											
36											

DF - Denver Formation

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW07	BAFB, Site 11 RI	117715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/16/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



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Lithology Log

Sheet 1 of 2

LOCID: 11MW05

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB, Site 11 - RI	111715.0003	3/16/09 - 1345	3/16/09 - 1530

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
Dakota Drilling	Gabe Kessel	Deborah Roth	29	29

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)
Brent Longyear 60	Hollow Stem Auger	7 1/4"	First 11.8' (Keck) - after well completion; ~~Final~~ 3/16/09 - 1730

Type of Sampling Device	Sample Hammer	Checked by/Date
Split Spoon (2')	Type: Safety Hammer; Driving Wt: 140 lbs; Drop: 30"	N Glenn 4/13/09

Location Description (include sketch in field logbook)

downgradient well in middle of field

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.7	8 10 14 10	0'-6': sandy silt; white CaCO3 deposits, fill material, traces of asphalt, fine sand (up to 30%), 10YR4/3 brown, no plas, soft	ML	SLSD	D	trace	5-30	70-95	
2			10 13 13 9								
4		1.7	5 5								
5		1.4	3 4 3 4								PID head space: 0 (4.7')
6				6-9.5': sandy silt; 10YR4/4 - dark yellowish brown, slight plas, stiff	ML	SLSD	D-M	trace	40	60	
7		1.4	2 3 3 3								
8											
9		1.6	3 6	9.5'-19': clayey, sandy silt; no definitive boundary w/above layer, white CaCO3 deposits, 10YR4/3 brown, slight plas, stiff	ML	SLCL/SLSD	M	trace	20	80	PID head space: 0 (9.6')
10			5 7 9 12								
12			11 13 15 16	13' - ~~sand~~ fine sand lens, well sorted, loose, wet, ~, 3' thick	SM		W	—	60	40	
14			11 13	14' - clayey silt → sand qty decreases to ~5%, lots of CaCO3	ML		M	—	5	95	
15		1.7	3 4 6 7								PID head space: 0 (15')
16											
17			7 7 6 7	SAA - 10YR5/4 - yellowish brown							
18											
19			6 6	19'-22': clayey silt (as above @14') / silty fine sand	ML/SM	SLCL/SDSL	W-S	—	5/70	95/30	PID head space: 0 (20')
20											

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Lithology Log (continued)

Sheet 2 of 2

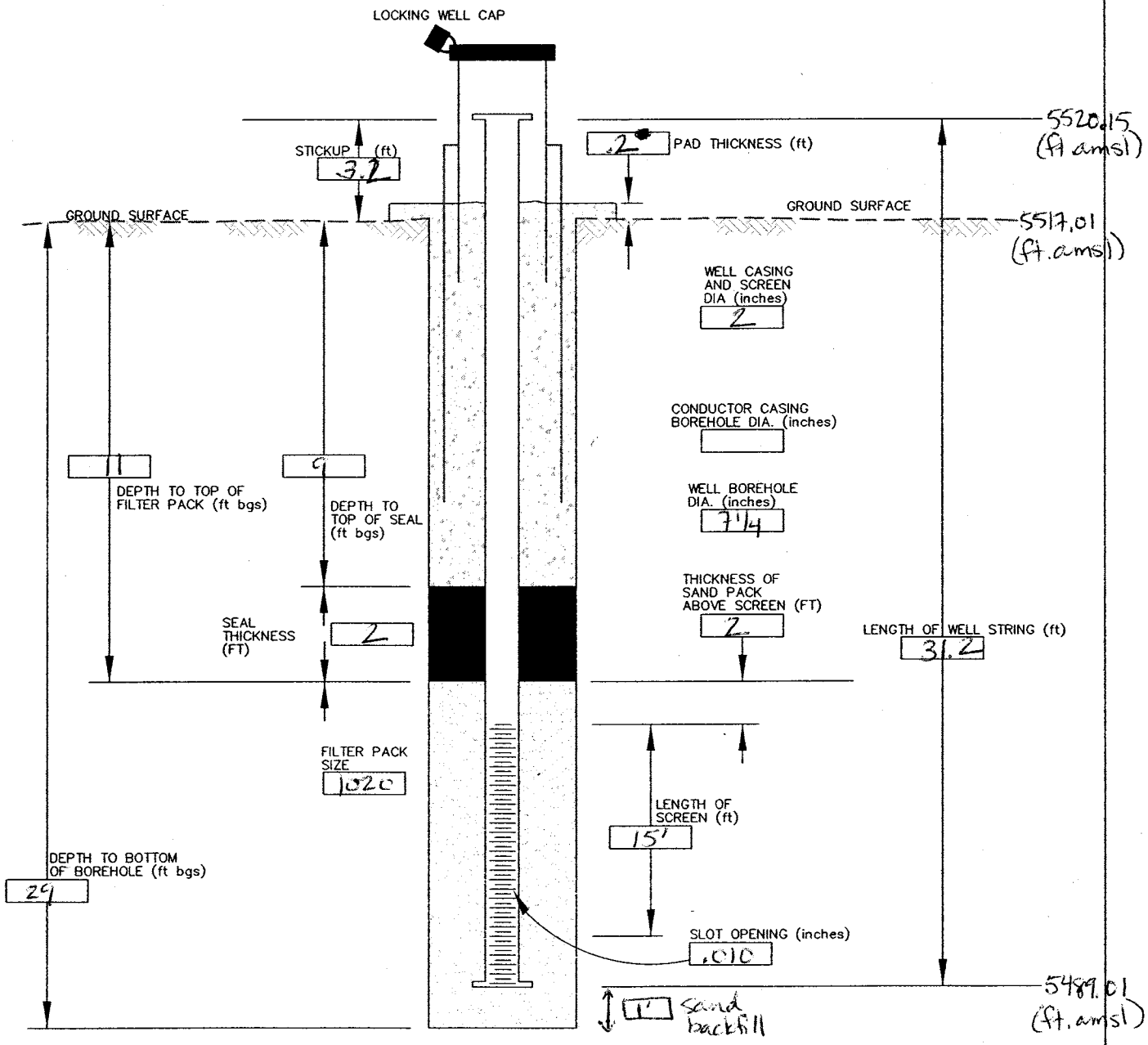
LOCID: 11MW08

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Estimate % of Sa	Estimate % of Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		1.0	2 4 5 8	varies from clayey silt to silty sand, fine-med sand, well sorted, 1/3"-6" layers of sand thin silt, 10YR5/4-yellowish brown, loose	ML/SM		W-S S6	— 20'	5/ to	30/ 95	
22			8 14 10 16	22'-26': silty fine med sand traces of coarse, well sorted, 10YR5/4-yellowish brown, loose	SM	SDSL	S	—	80	20	
24			10 8	24' - traces of gravel, 15% coarse, ~50% qtz, ~20% fsp, ~20% other				trace			PID head space: 0 (25')
25			4 8								
26			11 17	26'-27': silty fine sand some med sand, traces of clay, traces of coarse sand, iron staining, v. well sorted, 10YR4/4-dark yellowish brown, loose	SM	SDSL	M-W	—	60 to	20 40	
27			20 50/6 50/4								
28			48 50/4	27'-27.7': same as 22'-26' (fine-med sand + traces of gravel)	SM		W	trace	80	20	
29				27.7'-29: silty clay bedrock! odor, fractures iron staining, fractured, blocky, 10YR4/2-dark grayish brown, med. plas, v. stiff (milk chocolate)	CL	CLSL	D-M	—	—	100	
30											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW08	BAFB, Site 11-RI	111715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
3/16/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	4/13/09



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Lithology Log

Sheet 1 of 2

LOCID	
11MW09	

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB Site 11	11.17.15.0003	6/29/09 - 1000	6/29/09 - 1345

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
DAKOTA DRILLING	G. KESSEL	D ROTH	43'	43'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)	
BOART LONGYEAR 66	HOLLOW STEM AUGER	7 1/4"	First 27' (on 6/30/09)	Final 27.24 (7/7/09)

Type of Sampling Device	Sample Hammer	Checked by/Date
SPLIT SPOON (2'), CONTINUOUS SAMPLER (5')	Type SAFETY HAMMER, Driving Wt. 140 LBS, Drop 30"	NGlenn 8/26/09

Location Description (include sketch in field logbook)
NE CORNER OF PARKING LOT

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0			12 6	0'-1.5': SILTY, CLAYEY, FINE SAND; well sorted, loose, 10YR4/4 (dk. yellowish brown)	SM	SDSL	D	0	70	30	PID screen (0-2): 0
			8 8	1.5'-2': GRAVELLY, MED-COARSE SAND; med. sorted, loose, 10YR2/1 (black), asphalt chunks, fill material	SP	SDGR	D	5	95	0	
2			8 8 12 16	2'-3': MED SAND, v. well sorted, loose, 10YR6/3 (pale brown), ~85% qtz, ~10% fsp, ~1% other	SP	SDMD	D	0	100	0	PID screen (2-3): 0
4			12 12	4'-5': SAA, traces of coarse sand							PID screen (4-5): 0
5				5'-10': 0 recovery, assumed to be all dry sands, fell out of the bottom of the sampler							
6											
8											
10				10' - small layer of gravelly sand w/ asphalt (similar to 1.5'-2'); bedrock.							PID screen (10-12): 0
12				10'-11.5': SILTY CLAY; trace of fine sand, low-med. plas., soft, minor iron staining, 2.5Y5/3 (lt. olive brn.)	CL	CLSL	D-M	0	trace	100	
14				11.5-15.5: CLAYEY, SANDY, SILT; low plas., soft, 10YR4/6 (dk. yellowish brn), some iron staining, muse, flecks, sand is fine sand, 90% silt.	ML	SCCL	D-M	0	15	85	
15				15.5'-16.3: SILTY, CLAYEY, FINE SAND; v. well sorted, loose (dense in spots), 10YR4/3/6 (dk. yellowish brn.)	SM/SC	SDSL	D	0	80	20	PID screen (15-17.4): 0
16			24	16.3-16.5: SILTY FINE SAND, v. well sorted, ~~loose~~ dense, 7.5YR2.5/2 (v dark brn)	SM	SDSL	D	0	80	20	
18				16.5-20: SILTY, CLAYEY, FINE SAND; v. well sorted, dense (but can be crumbled), 10YR4/6 (dk yellowish brn.), only traces of clay, some iron staining	SM/SC	SDSL	D	0	80	20	
20											

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Lithology Log (continued) Sheet 2 of 2

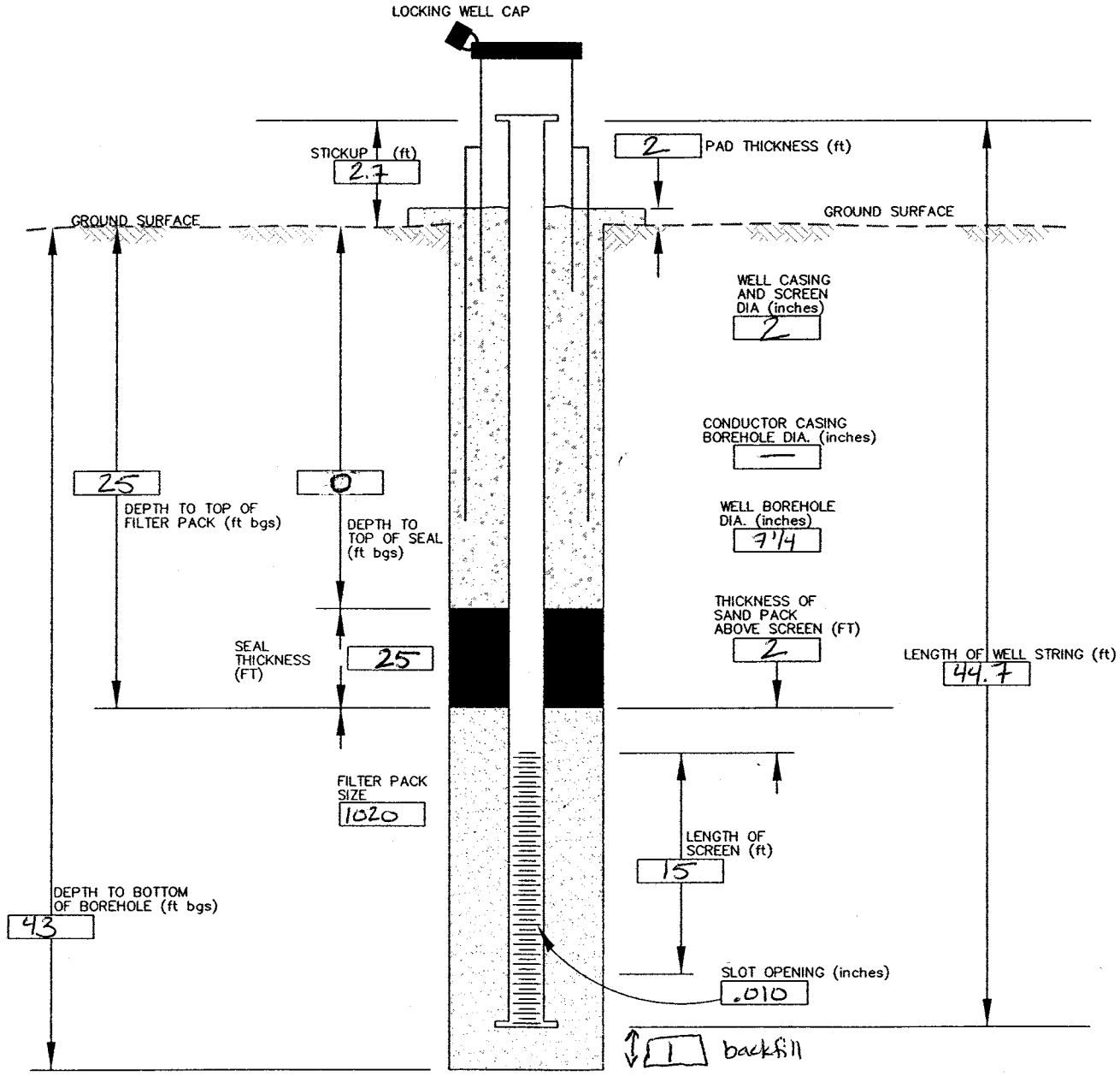
LOCID 11MW09

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		1.5		20-21.5: SAA, no clay, loose but v. dense in spots, traces of med. sand toward 21.5'	SM/SC	SDSL	D	0	80	20	PID screen: 0 PID head space (20-21.5): 0
22											
24											
25		1.7		25-25.4: SAA, lots of clay	SM/SC	SDCL	S	0	60	40	PID screen (25-30): 0
26				25.4-26.7: clayey silt; low plas, v. stiff, 2.5Y 5/3 (lt. olive brn), blocky, musc. flecks, iron staining, siltstone in parts	ML	SLCL	D	0	0	100	PID head space (26.7): 0
28											
30				30-30.6: CLAYSTONE; hard, iron staining, 10YR4/2 (dk. grayish brn.)	CL	CLST	D	0	0	100	PID screen (30-35): 0 PID head space (30): 0
32				30.6-31.2: SILTY CLAY; mod. plas (long worms - at least 3"), v. soft, 10YR4/4 (dk. yellowish brn), ~10% silt, ~90% clay	CL	CLSL	W	0	0	100	
				31.2-32.7: CLAYEY SILT; low plas, hard, 2.5Y4/1 (dk. gray), crumbly	ML	SLCL	D	0	0	100	
34				32.7-38.3: SILTSTONE; Denver Blue, low plas, hard, 6Ley1-5/N (gray), crumbly	ML	SLST	D	0	0	100	PID head space (34): 0
35											
36											
38				38.3-39: FINE-MED SAND; some clay & silt, 6Ley1-3/N (v. dk. gray), musc. flecks	SP-SC	SDFN	D	0	90	10	PID head space (38.3-39): 0
39		1.5		39-40.5: MED SAND; v. well sorted, loose (dense in places), 6Ley1-3/N (v. dk. gray), some clay	SP-SC	SDMD	S	0	90	10	
40											
42											
43											
44											
46											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW09	BAFB-Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
6/29/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N. Clem	8/26/09



COMMENTS: Screened 27'-42'

Filename: Q:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 3

LOCID: 11MW10

Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
BAFB - SITE 11	11.1715.0003	6/30/09 - 0845	6/30/09 - 1200

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
DAROTH DRILLING	G. KESSEL	D. ROTH	50'	50'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)
BIART LONGYEAR 66	HOLLOW STEM AUGER	7 1/4"	First 27.15 (7/1/09) Final 26.81 (7/8/09)

Type of Sampling Device	Sample Hammer	Checked by/Date
SPLIT SPOON (2') CONTINUOUS SAMPLER (5')	Type SAFETY HAMMER Driving Wt. 140 LBS Drop 30"	NGlenn 8/26/09

Location Description (include sketch in field logbook)

PARKING LOT, NW OF 11MW05

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.8	6 5 7 7	0-2.3: GRAVELLY SAND; poorly sorted, loose, 10YR3/3 (dk. brn), fill material, mixed w/silty clay	SW	SDGR	D	15	85	—	PID screen (0-2): 0
2		1.4	6 7 8 9	2.3-4: SILTY CLAY; low plas, v. stiff, 10YR4/4 (dk. yellowish brn.), ~40% silt, ~60% clay, white $CaCO_3$ deposits	CL	CLSL	D	0	0	100	PID screen (2-4): 0
4			6 7	4-5: CLAYEY, SILTY, FINE SAND; well sorted, loose, 10YR4/4 (dk. yellowish brn.)	SC/SM	SDCL	D	0	60	40	PID head space (4-5): 0
5		.8	5 5 7 12	5-5.8: CLAYEY, FINE SANDY, SILT; low plas, stiff, 10YR4/4 (dk. yellowish brn.)	ML	SLCL	D	0	15	85	PID screen (5-7): 0
6				5.8 → ~2" layer of med-coarse sand; well sorted, loose 10YR5/6 (yellowish brn)	SP-SM	SDMD	D	0	90	10	
7		1.8	12 17 25 27	7' → 2" layer of silt; traces of fine sand, 5YR2.5/1 (black) - closest, although layer is a darker black, bedrock	ML	SILT	D	0	trace	100	PID screen (7-9): 0
8				7.2-7.9: CLAYEY SILT, low plas, hard, 2.5Y6/4 (lt. yellowish brn), maybe 5-10% clay	ML	SLCL	D	0	0	100	PID head space (9-10): 0
9			30 37	7.9-10.9: SILT; low plas, v. stiff, 10YR5/3 (brn), blocky (like chocolate chunks), iron staining along fractures, ↑ clay w/depth	ML	SILT	D	0	0	100	PID screen (10-15): 0
10				10.9-16: SILTY, FINE SAND; v. well sorted, loose, 10YR4/6 (dk. yellowish brn)	SM	SDSL	D	0	75	25	
12		4.5									
14											PID head space (14.5): 0
15		1.55		15: SAA, now w/clay & ↓ sand	SM	SDSL	D	0	60	40	PID screen (15-20): 0
16				16-16.35: CLAYSTONE; low plas, hard, 2.5Y6/2 (lt. brownish gray), blocky, unweathered bedrock	CL	CLST	D	0	0	100	
18				16.35-20: * low recovery due to possible sands							
20											

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Lithology Log (continued) Sheet 2 of 3

LOCID: 11MW10

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20				20-20.5: SAA							PID screen (20-25): 0
		38		20.5-23.6: SILTY CLAY; low plas, soft, 10YR5/6 (yellowish brn); ~60% clay, ~40% silt	CL	CLSL	D	0	0	100	
22				22 - SAA, now 10YR5/2 (grayish brn), ~65% clay, ~35% silt, some iron staining							PID head space (23.8): 0
24				23.6-25.2: CLAYEY SILT, low plas, v. stiff, 2.5Y5/3 (lt. olive brn), blocky	ML	SLCL	D	0	0	100	
25				25.2-26.2: SILTY CLAY; low plas, soft, 2.5Y4/3 (olive brn), blocky, varies between silty clay & clayey silt from 25.2-31.6	CL	CLSL	D	0	0	100	PID screen (25-30): 0
26		27		26.2-26.7: CLAYEY SILT; low plas, soft, 10YR3/6 (dk. yellowish brn), traces of fine sand	ML	SLCL	D	0	trace	100	PID head space (27.7): 0
28				26.7-27.7: SILTY CLAY; low plas, v. stiff, 2.5Y5/3 (lt. olive brn), blocky, fractured, iron staining, some silt/clay stone pieces	CL	CLSL	D	0	0	100	
30		2		30-31.6: CLAYEY SILT; low plas, v. stiff, gley1-6/1-10y (greenish gray)	ML	SLCL	D	0	0	100	PID screen (30-35): 0
				30.7-31: SAA, now 2.5Y5/4 (lt. olive brn)							
32				31-31.6: SAA, now gley1-5/10y (greenish gray)							PID head space (32): 0
				31.6-32: CLAYEY, FINE SANDY, SILT; 10YR4/4 (dk. yellowish brn)	ML	SLCL	D	0	20	80	
34											
35		0		35-40: Ø recovery - most likely due to sands	SP?						
36											
38											
40				40-44: MED. SAND; v. well sorted, loose, 10YR3/6 (dk. yellowish brn), saturated towards 40', becomes W→S @41'	SP	SDMD	S W-S	0	100	0	PID screen (40-45): 0
42											
44				44-45: MED-COARSE SAND; mod. sorted, loose, 10YR3/6 (dk. yellowish brn), coarsens downward, traces of gravel towards 45'	SP	SDMD	W-S	0 trace	100	0	PID head space (45): 0
45											
46											

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Lithology Log (continued)

Sheet 3 of 3

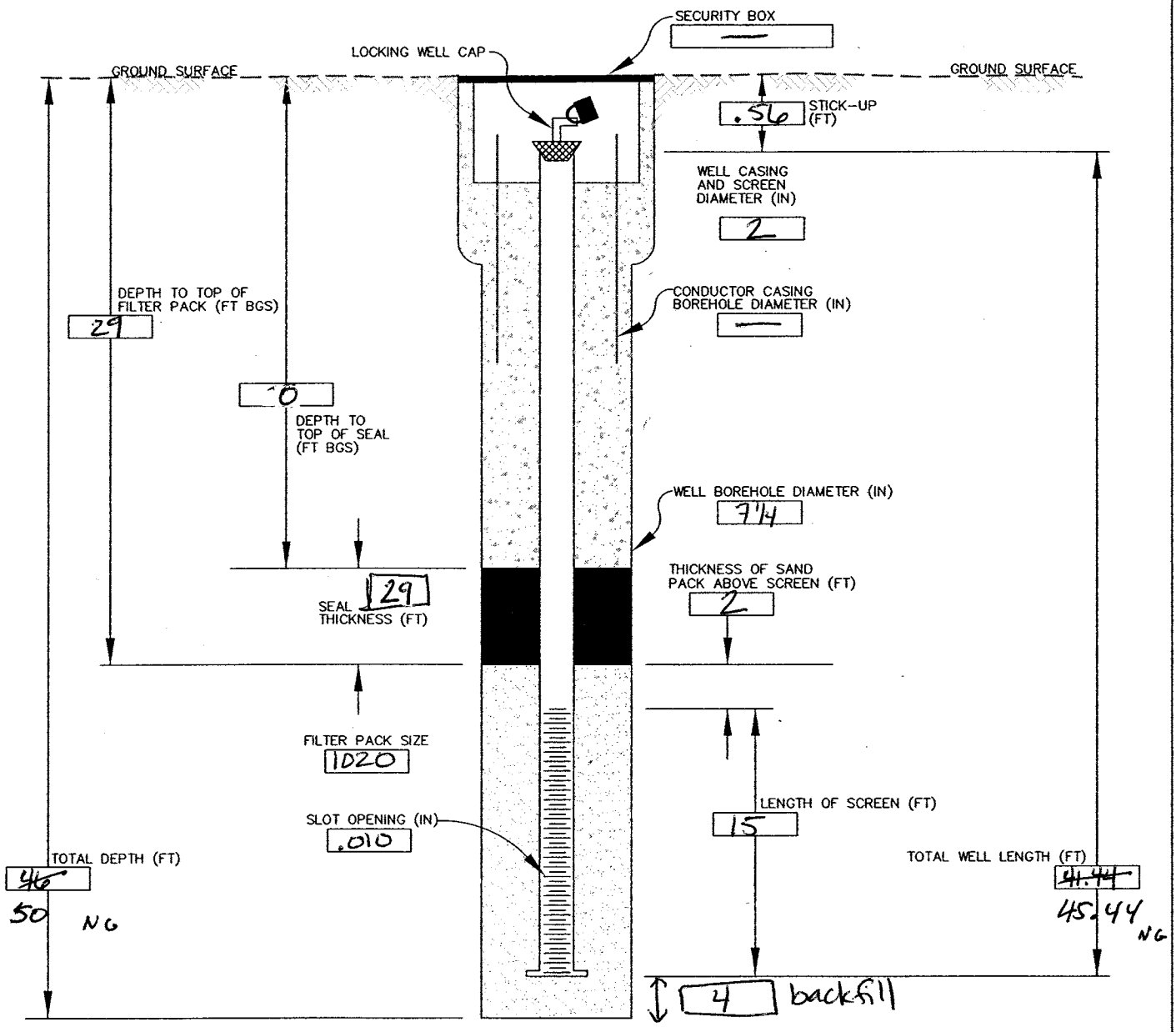
LOCID 11MW10

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
46				45-46.5: COARSE SAND; poorly sorted, dense, 10YR3/6 (dk. yellowish brn), traces of gravel	SW	SDCR	W-S	trace	100	0	
		4.5		46.5-48.5: FINE-MED SAND; well sorted, mod. dense, 5Y3/2 (dk. olive gray)	SP	SDFN	W-S	0	100	0	
48				48.5-49.5: SAA, now gley1-4/N (dk. gray)							PID head space (49.5): 0
50											
52											
54											
56											
58											
60											
62											
64											
66											
68											
70											
72											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Flush–Mount

Location ID:	Project Name:	Project #:
11MW10	BAFB-Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
6/30/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	8/26/09



COMMENTS: screened 31'-46'

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Lithology Log

Sheet 1 of 2

LOCID: MW01			
Project Name: BAFB SITE 11	Project Number: 11.1715.0003	Date/Time Drilling Started: 7/1/09 - 1130	Date/Time Total Depth Reached: 7/1/09 - 1500
Drilling Company: DAKOTA DRILLING	Driller: G. KESSEL	Hydrogeologist: D. ROTH	Total Depth Drilled: 45' / Total Depth Logged: 45'
Drilling Equipment: BOART LONGYEAR 66	Drilling Method: HOLLOW STEM AUGER	Borehole Diameter: 7 1/4"	Water Level (bgs): First / Final 26.22 (7/8/09)
Type of Sampling Device: SPLIT SPOON (2') CONTINUOUS SAMPLER (5')		Sample Hammer: Type SAFETY HAMMER, Driving Wt. 140 LBS, Drop 30"	Checked by/Date: NG 4mm 8/26/09

Location Description (include sketch in field logbook): EAST END OF PARKING LOT, NEAR WATER LINE

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		1.6	10 5 6 6	0-.6: GRAVELLY, SILTY, MED. SAND; poorly sorted, loose, 10YR4/3 (brn), fill material	SW-SM	SDGR	D	3	90	10	PID screen (0-2): .2-.4
2		1.4	7 8 9 10	.6-3: FINE SANDY, SILTY, CLAY; low-mod. plas, stiff, 10YR3/2 (v. dk. grayish brn), sand varies up to 40%	CL	CLSD	D	0	25-40	60-75	PID screen (2-4): 0
4			9 10	3-4: SILTY, FINE SAND, well sorted, loose, 10YR5/3 (brn), ~70% qtz, ~25% fsp, ~5% other	SP	SDFN	D	0	95	5	
5		1.8	6 6	4-5: MED. SAND; mod-well sorted, loose, 10YR5/4 (yellowish brn), ~7% coarse sand		SDMD	D	0	100	0	PID head space (4-5): 0
6			8 9	5-5.5: SILTY, FINE SANDY, CLAY; low plas, v. stiff, 10YR3/3 (dk. brn)	CL	CLSL	D	0	3	97	PID screen (5-7): 0
7		1.1	13 13	5.5-11: FINE-MED SAND; mod. sorted, loose, v. clean, 10YR5/4 (yellowish brn), ~2% coarse sand, coarsens downward	SP	SDFN	D	0	100	0	PID screen (7-9): 0
8			13 13	6.5: mod-poorly sorted, 7% coarse							
9			13 13	9: poorly sorted, 15% coarse							PID head space (9-10): 0
10		1.5	10 8 9 10	11-13.2: SILTY CLAY; low-mod. plas, v. stiff, 10YR4/3 (brn), iron staining, crumbly, plas. ↓ w/depth, bedrock	CL	CLSL	D	0	0	100	PID screen (10-12): 0
12			16 22 39 50/6	13.2-15: CLAYEY SILT; low plas, hard, 10YR3/6 (dk. yellowish brn), very little clay, iron staining, bedding layers	ML	SLCL	D-M	0	0	100	PID screen (12-14): 0
14		.3	50/3								PID head space (14-15): 0
15				15-21.2: SILTY, FINE SAND; well-v. well sorted, loose (dense in spots), 7.5YR3/3 (dk. brn), some clay in spots							PID screen (15-20): 0
16		2.5			SM	SDSL	D-M	0	60-70	30-40	
18											
20											PID head space (17.5): 0

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Lithology Log (continued) Sheet 2 of 2

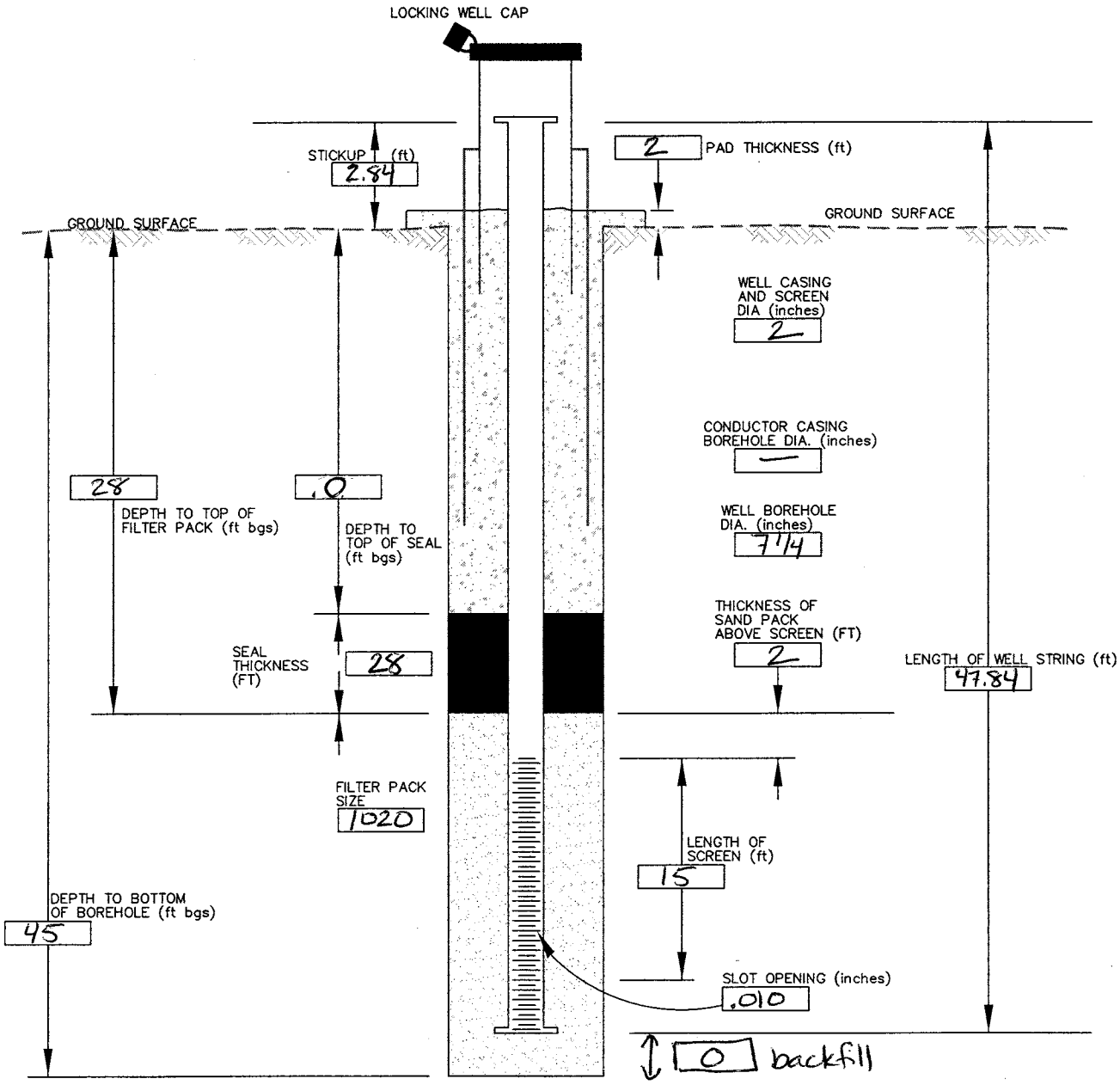
LOCID: 11MW11

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		2.6		20-20.2: SILTY CLAY; low-mod plas, v.soft 2.5Y6/3(lt.yellowish brn)	CL		W	0	0	100	PID screen(20-25): 0
				20.2-21.2: SA SILTY, FINE SAND ABOVE, now 2.5Y5/2(grayish brn)	SM	SDSL	D	0	60	40	
22				21.2-25: SILTY CLAY, low plas, v.soft, 2.5Y5/4(lt. olive brn), crumbly, iron staining, varies in color to 5Y7/1(lt.gray)	CL		D	0	0	100	PID head space(22.6): 0
24											
25				25-25.2: CLAYSTONE; 5Y5/2(olive gray), iron staining	CL	CLST	W	0	0	100	PID screen(25-30): .1
26		2.8		25.2-31: CLAYEY, SANDY SILT; 2.5Y4/3 (olive brn), iron staining			D-M	0	15	85	
				26.2-sand↓, clay↑			D-M	0	3	97	
28				27-clay↓							PID head space(27.8): 0
				clay content varies, color varies to 10YR4/4(dk. yellowish brn), crumbly							
					ML	SLCL					
30											PID screen(30-35): 0
		3.2		31-37.5: CLAYEY SILT; Denver Blue, low plas, soft, gley1-5/N(gray), crumbly, some iron staining			D	0	0	100	
32											
											PID head space(33.2): 0
34											
35											PID screen(35-40): 0
36											
		4.4		37.5-45: MED SAND; v. well sorted, loose (dense in spots), 10YR4/6 (dk. yellowish brn), traces of coarse w/depth, wet @ 40'		SDMD	D-M	0	100	0	
38											
40					SP		W	0	100	0	
42											
		4.5		43-44: MED-COARSE SAND, mod. sorted, loose(dense in spots), 7.5YR3/3 (dk.brn)		SDMD	W-S	0	100	0	
44				44-44.5: FINE-MED SAND, v. well sorted, dense, 7.5YR4/3(brn)		SDFM	W	0	100	0	
45											
46											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW11	BAFB-Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
7/1/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N Glenn	8/26/09



COMMENTS: Screened 30'-45'

filename: G:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 2

LOCID: 11MW012			
Project Name: BAFB SITE 11	Project Number: 11.1715.0003	Date/Time Drilling Started: 6/29/09 - 1610	Date/Time Total Depth Reached: 6/29/09 - 1740
Drilling Company: DAKOTA DRILLING	Driller: G. KESSEL	Hydrogeologist: D. ROTH	Total Depth Drilled: 21.5' / Total Depth Logged: 21.5'
Drilling Equipment: BOART LONGYEAR 66	Drilling Method: HOLLOW STEM AUGER	Borehole Diameter: 7 1/4"	Water Level (bgs): First / Final 8.95 (7/6/09)
Type of Sampling Device: SPLIT SPOON (2')	Sample Hammer: Type SAFETY HAMMER	Driving Wt. 140 LBS Drop 30"	Checked by/Date: N Glenn 8/26/09

Location Description (include sketch in field logbook): SOUTH END OF PERIMETER ROAD, JUST NORTH OF 11MW01

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0			6 5 5	0-.5: GRAVELLY SAND; fill, v.poorly sorted, loose, 10YR2/1 (black), asphalt chunks	SW	SDGR	D	35	60	5	
2		1.2	6 6 7 11 12	.5-7: SILTY CLAY; low plas, v.stiff, 7.5YR3/2 (dk. brown), ~15% silt, ~85% clay	CL	CLSL	D	0	0	100	
4			12 11	4-5: SAA, 10YR3/2 (v. dark grayish brn), ~40% silt, 60% clay, more silt than above							
5			6 8 8 10								PID head space (5): 0
6											
7			9 11 12 12	7-9: CLAYEY, SILTY, FINE SAND; well sorted, loose, 10YR3/3 (dk. brown)	SM/SC	SDCL	D-M	0	80	20	
8											
9			14 14	9-15: SILTY CLAY; low-mod. plas, soft, 10YR3/2 (v. dk. grayish brn), SA .5'-7'	CL	CLSL	D-M	0	0	100	
10			5 8 8 9	11': traces of fine-med sand			D-M	0	trace	100	PID head space (10): 0
12			9 11 9 10	13-14.5: mod. plas, .05' layers of wet, med. sand @ 13' & 13.5', med sand layers still have lots of clay & silt, v. soft, 10YR3/4 (dk. yellowish brn)	CL	CLSL	M W	0 0	trace 70	100 30	
14			8 6								PID head space (14.5'): 1.5
15		1.6	3 4 5 5	15-18.4: CLAYEY, FINE-MED SANDY, SILT; mod. plas, med. soft, 10YR3/4 (dk. yellowish brn) 16-17: SILTY CLAY	ML/CL	SLCL	S	0	30	70	
16											
17			3 5	17-18: CLAYEY SILT 18-18.4: SILTY CLAY							
18			5 7	18.4-19: CLAYEY, SILTY, FINE SAND; well sorted, loose, 10YR5/6 (yellowish brn), iron staining, traces of med. sand, bedrock	SM	SDCL	M-W	0	60	40	
19			10 20	19-22: SAA, now 80% sand, iron staining, black staining, less clay	SM	SDFN	D-M	0	80	20	PID head space (20): 0.5
20											

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Lithology Log (continued)

Sheet 2 of 2

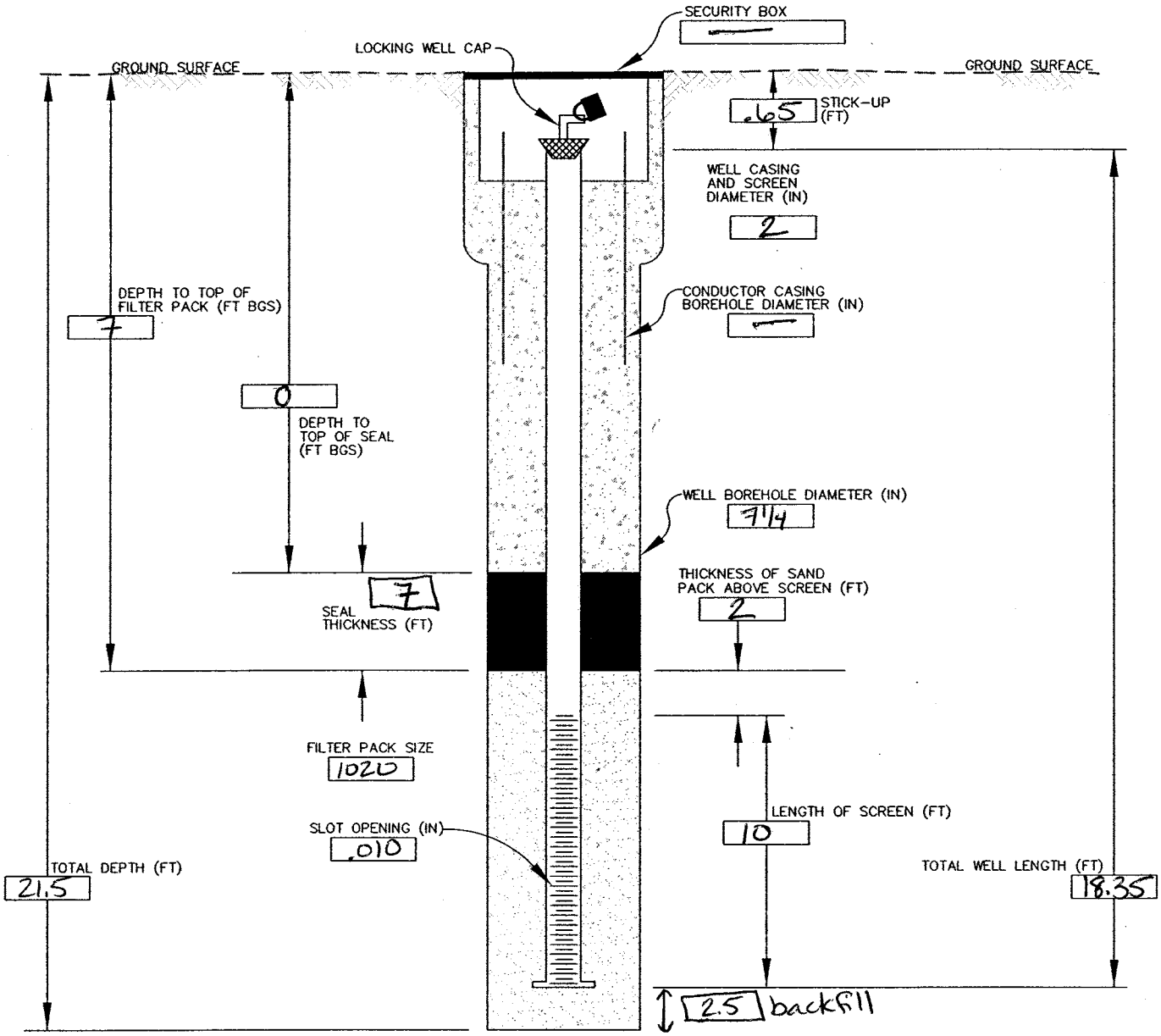
LOCID 11MW12

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20	↓	↓	19 38 50/6	SAA	SM	SDFN	D-M	0	80	20	
22											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Flush-Mount

Location ID:	Project Name:	Project #:
11MW12	BAFB-Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
6/29/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	Nan Glenn	8/26/09



COMMENTS: Screened 9'-19'

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Lithology Log

Sheet 1 of 2

LOCID	Project Name	Project Number	Date/Time Drilling Started	Date/Time Total Depth Reached
11MW13	BAFB SITE 11	11.1715.0003	6/30/09 - 1450	6/30/09 - 1817

Drilling Company	Driller	Hydrogeologist	Total Depth Drilled	Total Depth Logged
DAKOTA DRILLING	G. KESSEL	D. ROTH	32'	32'

Drilling Equipment	Drilling Method	Borehole Diameter	Water Level (bgs)	
BOART LONGYEAR 60	HOLLOW STEM AUGER	7 1/4"	First	Final 13.78 (7/6/09)

Type of Sampling Device	Sample Hammer	Checked by/Date
SPLIT SPOON (2')	Type SAFETY HAMMER; Driving Wt. 140 LBS; Drop 30"	N Glenn 8/26/09

Location Description (include sketch in field logbook)

NEAR 11MW08 IN FIELD

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0			5 6 17 6	0-2.6: GRAVELLY SAND; poorly sorted, loose, 10YR4/2 (dk. grayish brn)	SW	SDGR	D	3	92	5	PID screen (0-2): 0
2		1.4	6 6 7 8	2.6-10: SILTY CLAY; low-mod. plas, med. soft, 2.5Y5/1 (gray) 3: SAA, now w/some fine-med sand	CL	CLSL	D	0 0	0 5	100 95	PID screen (2-4): 0
4		.7	9 10								PID head space (4-5): 0
5			6 6 6 7	5: SAA, less sand			D	0	3	97	PID screen (5-7): 0
6											
7			5 6 6 7	7: SAA, less sand			D	0	trace	100	PID screen (7-9): 0
8		1.6									
9			4 4	9: SAA, sand back @ 5%, white $CaCO_3$ deposits			D	0	5	95	PID head space (9-10): 0
10		1.3	3 3 4 4	10-11.3: CLAYEY, SILTY, SAND; well sorted, loose, 10YR4/4 (dk. yellowish brown)	SM/SC	SDCL	D	0	60	40	PID screen (10-12): 0
12		1.4	1 2 3 2	12-26: SANDY, SILTY, CLAY; fine sands, mod. plas, soft, 10YR3/3 (dk. brown)	CL	CLSD	D	0	20	80	PID screen (12-14): .6 @ 12.7'
14			3 6	14: sands ↓ to 5%, white $CaCO_3$ deposits			D-M	0	5	95	PID head space (14-15): 0
15			3 5 6 6	15: sands ↑ to 15%			D-M	0	15	85	PID screen (15-17): 0
16											
17			4 4 5 5	17: sands ↑ to 30%			M	0	30	70	PID screen (17-19): 0
18											
19			5 6	19: 10YR4/4 (dk. yellowish brown)							PID head space (19-20): 0
20											

Versar INC.

Lithology Log (continued) Sheet 2 of 2

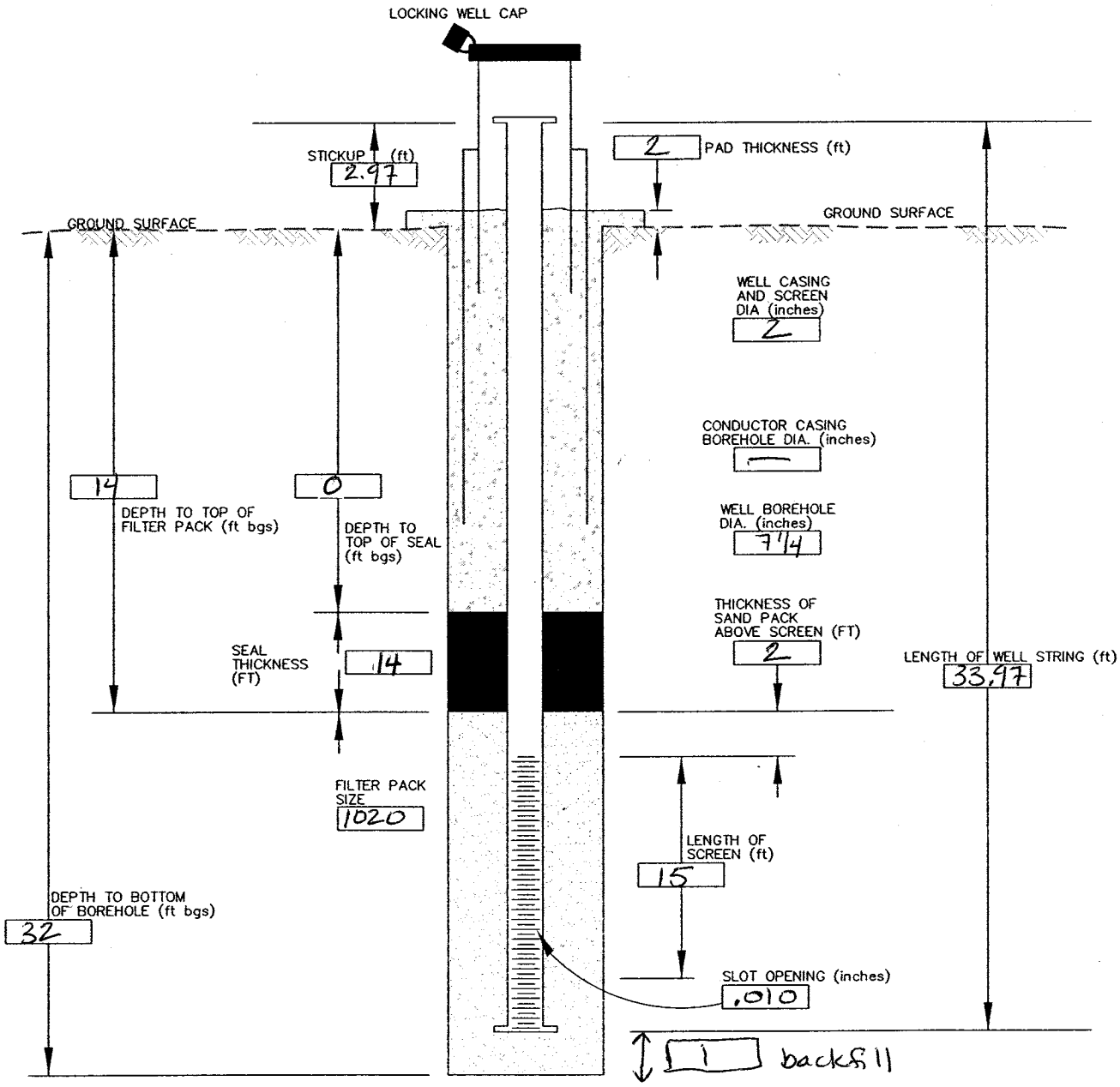
LOCID: 11MW13

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20		1.4	2 3 3 4	20-20.8: SAA, now wet			W	0	30	70	PID screen (20-22): 0
				20.8-26: SAA, ↑sand, mod plas, ↓soft, 10YR5/6 (yellowish brown)			W	0	40	60	
22			4 4 5 6	22: saturated	CL	CLSD	S	0	40	60	PID screen (22-24): 0
				23: wet, traces of gravel			W	trace	40	60	PID head space (24-25): 0
24			2 4	24: saturated			S	trace	40	60	
25			8								PID screen (25-27): 0
26		1.8	9 12 14	26-30.5: FINE-MED SAND; well-v.well sorted (becomes mod. sorted w/ depth), loose,			S	0	100	0	
27			4 8 7 9	27: 5-15% coarse sand, traces of gravel, coarsens downward to med sand w/ more coarse grains	SP	SDFN	S	trace	100	0	PID screen (27-29): 0
28											PID head space (29-30): 0
29			6 14								
30			11 21 22 23	30.5-30.8: CLAYEY, MED. SAND; mod-poorly sorted, 10YR4/4 (dk. yellowish brown)	SC	SDCL	W	0	60	40	
32				30.8-31.2: SILTY, FINE SAND; well-v.well sorted, 10YR3/6 (dk. yellowish brown)	SM	SDSL	M	0	80	20	
34				31.2-32: CLAYSTONE; fractured, iron staining, 10YR4/3 (brown), bedrock	CL	CLST	D	0	0	100	
36											
38											
40											
42											
44											
46											

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW13	BAFB-Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
6/30/09	Hollow Stem Auger	PVC
Geologist:	**Checked By:**	**Date:**
D. Roth	N. Glenn	8/26/09



COMMENTS: Screened 16' - 31'

Filename: G:\FIELD-FORMS-WELL\WELCONS3-032906.dwg PLOTTED: 3/29/06

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Lithology Log

Sheet 1 of 1

LOCID: 11MW14			
Project Name: BAFB Site 11	Project Number: 11.1715.0003	Date/Time Drilling Started: 5/27/10 1250	Date/Time Total Depth Reached: 5/27/10 1300
Drilling Company: Site Services	Driller: Brian Dechart	Hydrogeologist: N Glenn	Total Depth Drilled: 19 ft / Total Depth Logged: —
Drilling Equipment: Geoprobe 7730DT	Drilling Method: Direct push	Borehole Diameter: 3 inches	Water Level (bgs): First None / Final
Type of Sampling Device: None	Sample Hammer: Type / Driving Wt. / Drop		Checked by/Date

Location Description (include sketch in field logbook)

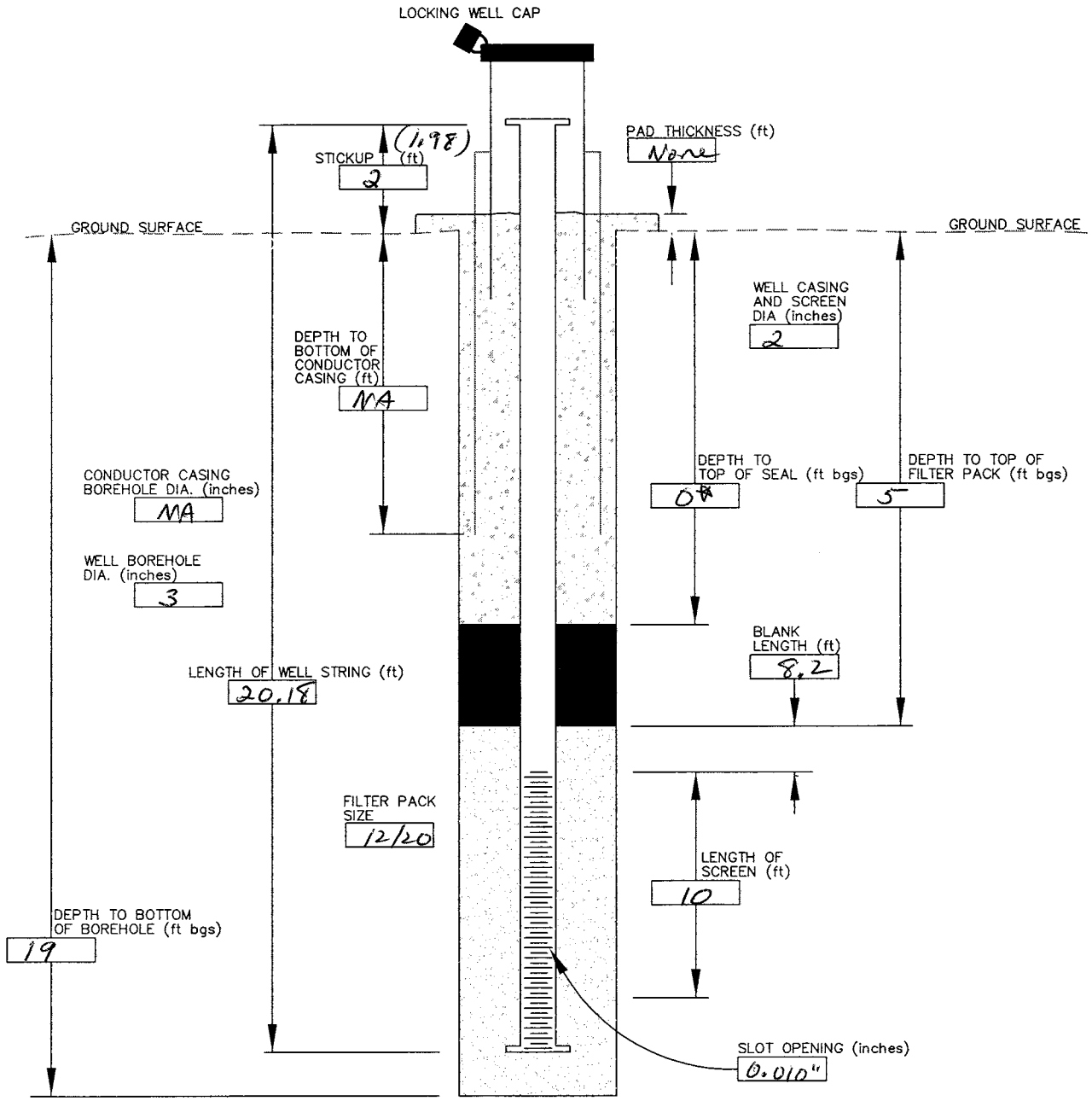
North of East Toll Gate Creek, 2 feet from DP 69

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc. as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				None obtained - so No IDW to transport							

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID:	Project Name:	Project #:
11MW14	BAFB Site 11	11.1715.0003
Construction Date:	**Drilling Method:**	**Casing/Screen Material:**
5/27/10	Direct-push	PVC
Geologist:	**Checked By:**	**Date:**
N Glenn		



COMMENTS: NA - not applicable

*Seal & Grout - Bentonite chips from 0 to 5 ft bgs

filename: Q:\FIELD-FORMS-WELL\WELCONS3.dwg PLOTTED: 12/13/05

Versar INC.

Lithology Log

Sheet 1 of 2

Project Name: BAFB-Site 11	Project Number: 1118371837.002	Date/Time Drilling Started: 6/21/10 0900	Date/Time Total Depth Reached: 6/21/10 at 1300
Drilling Company: Patota Daley	Driller: Gabe Hessel	Hydrogeologist: Chet Pope	Total Depth Drilled: 37'4" / Total Depth Logged: 37'
Drilling Equipment: BOART Longyear	Drilling Method: Hollow Stem	Borehole Diameter: 7¼	Water Level (bgs): First None / Final
Type of Sampling Device: CME 2" Split Spoon	Sample Hammer: Type Safety/Hammer, Driving Wt. 140, Drop 30"		Checked by/Date: N Glenn 6/28/10

LOCID: 11MW15

Location Description (include sketch in field logbook): 35' SW of 1011MW07

(PID Bkgd = 4.0 ppm)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc. as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
			4 4 6 7	4" asphalt pad; 0'-5' clays; slightly silty, sandy, wooden (7.5YR 4/4) no stain; high plasticity; some caliche; <10% S	CL	Clay	SM	<5	<5	90	
2			6 9	same slightly moist; soft			M				
4			12 13 14	(7.5YR 4/4 – 10YR 4/6) color change at 4'	CL		m	<5	<5	90	PID 0-5' = 6.2
5 6			6 6 7	5'-9.6" minor SOS or silts <10%							
7 8			10 7 7	10YR 5/6 clays- slightly silty, sandy high plasticity; minor SOS or silts; soft	CL	Clay	m	<5	<5	90	
9			8 8 10	9.6"–10.6" clean sands, coarse to fine gravels, rounded to well rounded, qtz 50% feldspars 25% micas-25% (10YR 6/4) GRAINS to ½" diam	SW-SM	SAND SD	D	20	70	<10	P.D 5-10 = 5.8
10 11			49 21 29	LOOSE – granule pebbles ~1" diam							
12			45 31 44	10.6'-17' weathered claystone (yellowish brown) siltstone; claystone; Bedrock (2.5Y 6/6)	claystone siltstone (CLML)		D	<5	<5	90	
13			47 50/5	color change at 13'; blocky, Iron stained (7.5YR 5/8) DRY, No odor, no stain			D				
14			48 50/5	same color change at 13' 8" to 2.5Y 5/6 reddish brown, Blocky hard;	claystone siltstone		D	<5	<5	90	PID 10-15 = 4.0
15 16			25 27 33	same; color change at 15' – 2.5Y 7/4 some Iron staining; Blocky/platty	claystone		D	<5	<5	90	
17			47 42 50/5	same; claystone; slightly silty 2.5Y 7/8 Blocky; hard;	claystone		D	<5	<5	90	
18			28 48 50/5	18.6" (19.5') sandstone; siltstone; vitr to fr sandstone; micaceous 2.5Y 7/8	sandstone siltstone (ML)	SSSL	D	<5	40	55	PID 15-20' = 3.6
20			50/5								

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Lithology Log (continued) Sheet 2 of 2

LOCID: 11 MW15

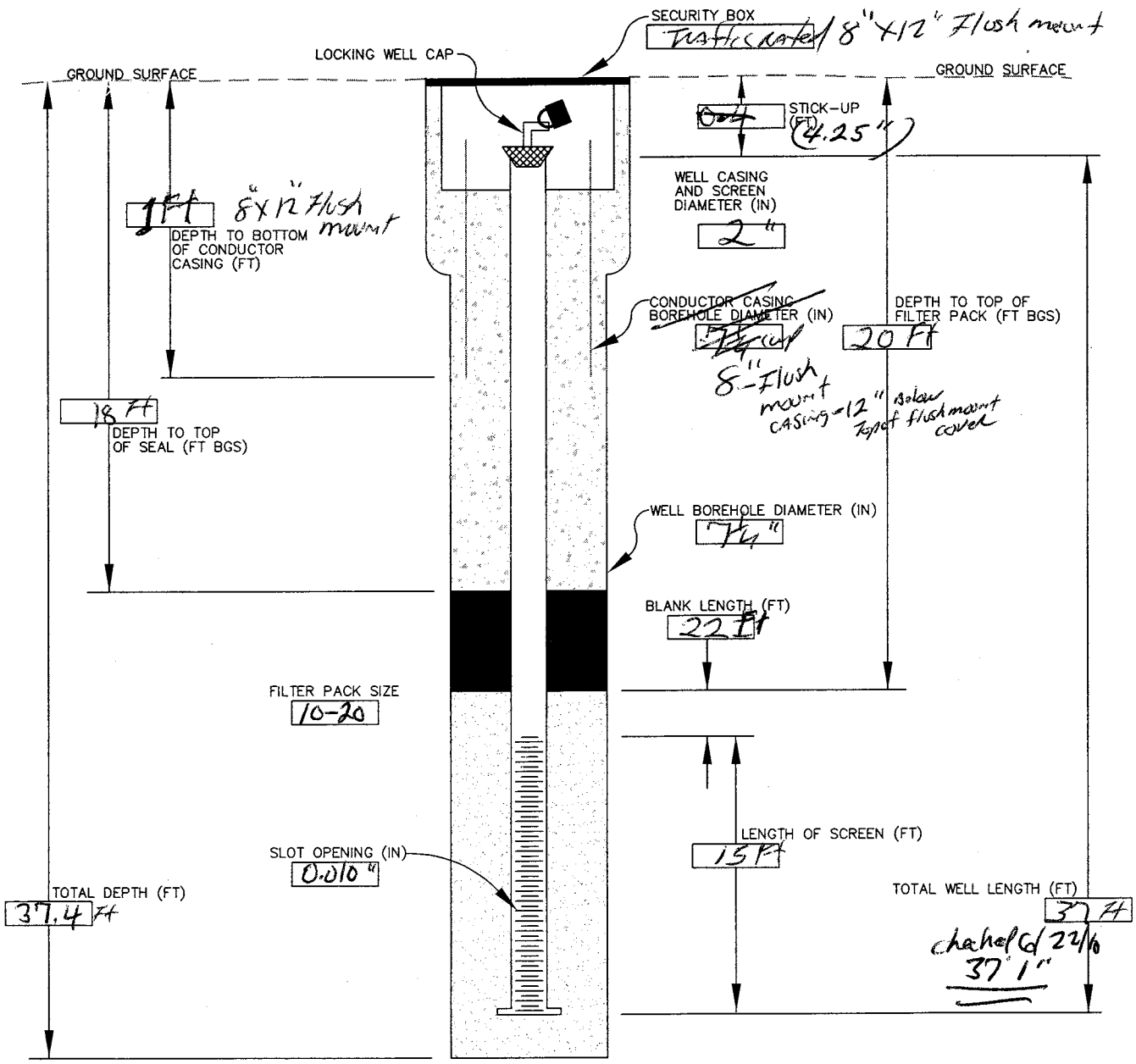
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
20			27 35 50/5	sandstone; siltstone, v.fn to fn sds micaceous; 2.5Y 7/6, clays <20%	sandstone siltstone		d-m	15	40	60	Bkgrd PID = 1.5
21.5			26 41 50/4	med to fn sd; unconsolidated, coarse at depth, micaceous, 10YR 5/6 qtz = 60%; feldspars 25% rock frag. 15%	sandstone (SM)	SS	m	15	60	40	
22											
23			27 50/5	same; yellowish Brown							PID = 20-25' = 2.8
24			32 49	24.0' claystone; Grey; Grey 2 5/5B Blocky, Iron staining	claystone (CL)	CLST	0	0	0	100	
25			27 39 48 50/4	same; Blocky claystone; grey Iron staining; no sands; <5% silts	claystone		0	0	0	100	
26			28 40 50/4	28'6"			0	0	0	100	
28'6"			38 48 50/4	sandstone; 10YR 6/6 v.fn to fn sds micaceous; silty; yellowish Brown silty sand, sands	sandstone (SM)	SS	d-m	0	80	20	PID 25-30' = 1.0
29			38 50/5	same v.fn sand; silty, clayey				0	70	30	
30			42 50/5	31.0 claystone; grey; slightly silty Grey 2 5/5B	(CL)	CLST		0	0	100	
31			41 50/5	same; Blocky			0				
32			41 50/5	claystone; slight increase silts	claystone			0	0	100	PID 30-35' = 0.0
33			39 50/5	34.0 sand/sandstone; medium to fn sand 10YR 4/4 v. unconsolidated	(SM)	SS			80	20	
34			31 50/5	grey claystone; Grey 2 6/5B Blocky 35.0	claystone (CL)	CLST		0	0	100	PID 35-37' = 0.0
35'			39 50/5	Blocky, hard;							
36				Denver Blue at 36'-37'	claystone			0	0	100	
37				claystone Grey 2 6/5B							
38				T.D. boring at 37 Dec Nam Gray well set 15' screen; 0.010" slotted screen;							

Recd 6/21/10

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Flush–Mount

Location ID: 11mw15 Site 11 BAFB	Project Name: BAFB Site 11	Project #: 11837/837.02
Construction Date: 6/21/10	Drilling Method: Hollow Stem	Casing/Screen Material: PVC
Geologist: Cup	Checked By: N Glenn	Date: 6/21/10



COMMENTS:

filename: Q: \D-FORMS-WELL\WELCONS4.dwg PLOTTED: 12/13/05

Versar INC.

Lithology Log

Sheet 1 of 2

Project Name: BAFB-Site 11	Project Number: 1117837.1837.002	Date/Time Drilling Started: 6/22/10 0800	Date/Time Total Depth Reached: 6/22/10 1045
Drilling Company: Dakota Drilg	Driller: Gabe Hessel	Hydrogeologist: Cliff Pope	Total Depth Drilled: 36'6" / Total Depth Logged: 36'6"
Drilling Equipment: Boart Longyear CM66	Drilling Method: Hollowstem	Borehole Diameter: 7 1/4"	Water Level (bgs) First: 20.36' bgs (Top of casing) / Final
Type of Sampling Device: 2' split spoon	Sample Hammer: Type Safety Hammer, Driving Wt. 140 lb, Drop 30"		Checked by/Date: N Glenn 6/28/10

Location Description (include sketch in field logbook): 40' West-SW of Former well 10llmw06

LOCID: 11mw16

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc. as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks: color (Include all sample types & depth, odor, organic vapor measurements, etc.)
0			6 7 7 7	fine to coarse sands silty; clays < 20% 10YR 6/6 No odor, no stain. – roots (fill loose	SM	SAND SD	D		80	20	
2			8	SAME							
3			18	3'			GRSD				fill? PID 0-5 = 0
4			17 10 7 9	gravels; gravelly sands (fill); gravels to 2" diam; well rounded; gt > 70% feldspar 25%	SW-SM	GM-SM	D	40	40	20	color 10 YR 6/6 – fill?
5			5	Silty clays; high plasticity, soft	CL		m	10	10	80	10 Y 4/3 – 10 YR 5/6 fill?
6			7 5 7	silty clayey sands; sandy clays mixed; caliche; 6'6"	SM/SC	SOIL	m	40	40	50	10 Y 4/4
7			6 5 4 4	fine to medium sands; rounded to well rounded, silty frosted grains; loose;	SW-SM	SAND SD	m		90	10	10 Y 5/4
8			3 3 3	SAME (note some thin clay layers in sands < 2-3" thick)	SW-SM		m		90	10	10 Y 5/4
10			3 3 2 2	SAME slightly silty; soft	SM		m		80	20	10 Y 5/6 PID 5'-10' = 0
12			3 3	SAME increase in fines – clays & silts soft 13'							
14			3 4 3	clayey sands, sandy clays; silty soft; sand mixtures	CL/SC	SOIL	m		70	30	10 Y 4/6
15			4 3	SAME increase in sands at bottom			m		80	20	PID 10-15' = 0
16			3 3 4	15'4" clays, silty clays; (black) slightly sandy < 5%; some coarse sands high plasticity – to medium plasticity	CL	CLAY	m		20	80	10YR 2/1 dk gray to black (no odor) PID = 0 at 16-19'
18			5 7 7 9	caliche zones; micaceous; soft medium plasticity			m vm				10 YR 4/6 at 19' very moist at 18.5 =
20			8 10	clays; silty clays, sds < 10%			m				PID 15-20' = 0

Versar INC.

Lithology Log (continued) Sheet 2 of 2

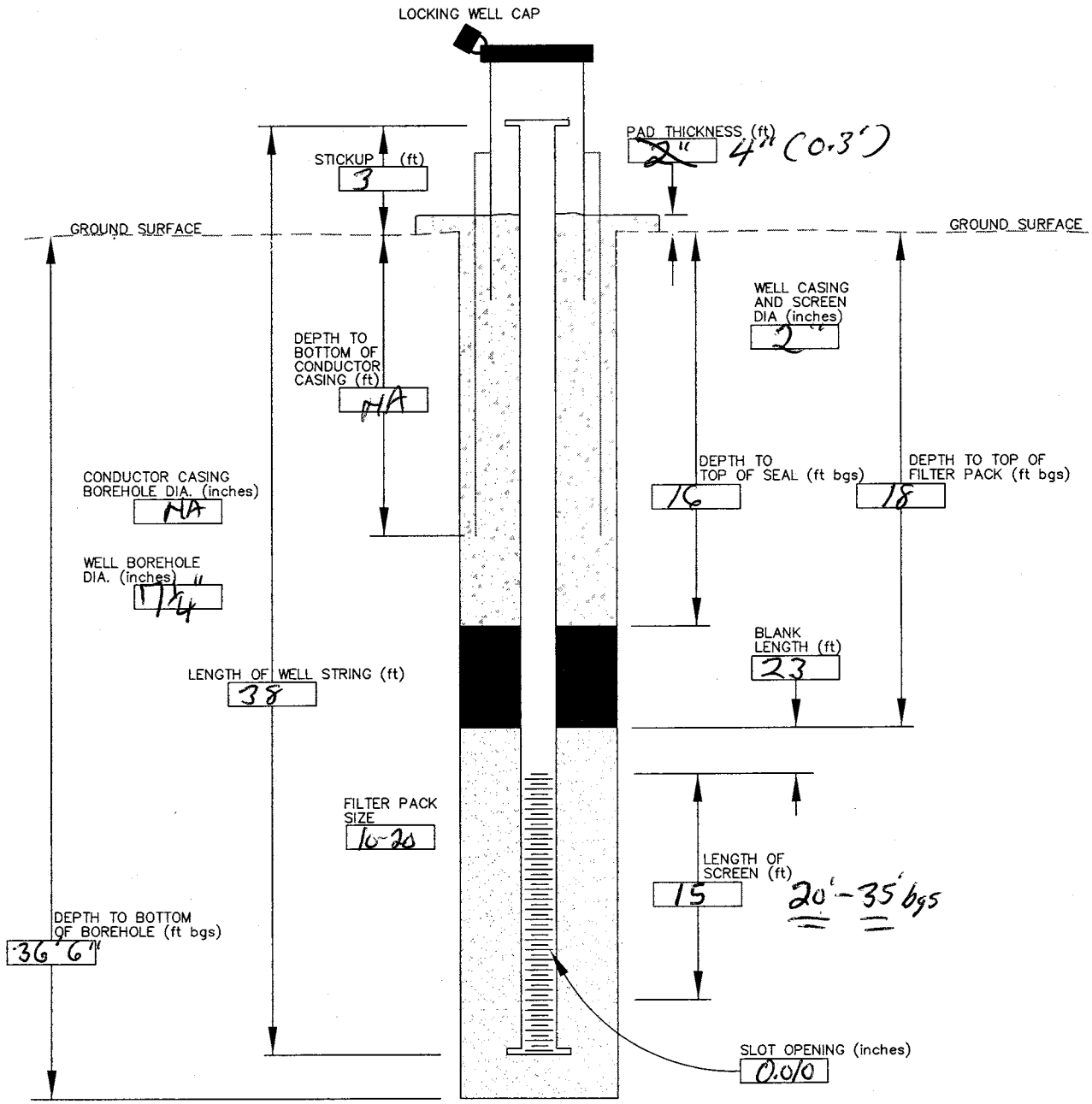
LOCID: 11MW16

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)	
20			4	Clays, silty clays; slightly sandy	CL	clay	m		15	85	10 YR 5/6	
21			5	clays; soft sands < 5%								
			6	some caliche pockets; medium to								
22			5	high plasticity								
			3	Same silty								
23			4	slight increase in sands	CL/SC	clays	m-vm		20	80	10 YR 5/6	
			5	fine to medium sands; < 10%								
24			5	moisture increase with depth [24']							water at 24-24.5'	
			3	silty clayey sands, sandy clays,	SM	SDCL	W		60	40	10 YR 5/6	PID-20-25' =
25			4	clays < 15%; very silty no odor	-SC	clay						0
			2	soft		CLSL						
26			3	Same → high plasticity;	SC-CL		m-W		40	60	same	
			3	increase in clays - micaceous		clay						
27			3								10 YR 5/6 - 6/6	
			3	soft - very soft			m-W					
28			4	slightly sandy clays.					40	60		PID-25-30'
			6	Same; silty clays, clays - minor coarse	SC-CL	clay	m-W					0
29			8	sands < 5%								
			6	Same - less moisture at bottom			m				10 YR 6/6	
30			7	High plasticity, very soft								
			3									
31			5	[31'6"]								
			9	fine to med. sand; qtz - 70%; feldspars 20%	SW	SAND	W	<10	85	<5	10 YR 4/6	PID-30-35' =
32			12	mafics, 10%; frosted - well rounded; loose		SD						0
			7	to sub rounded								
			17	Same some coarse sand zones < 2"	SW		W	<10	90	0	10 YR 4/4	
			37	thick; up to pea size; loose								
			59/5	well rounded, rounded; frosted;								
34			59/4	Same - loose sand [35']	SW		W	<10	90	0		
35			23	Claystone Bedrock - weathered	Bedrock	CLST	D	0	0	100	10 YR 5/6	35-36'6"
			39	At 35'; blocky; iron stained	Claystone		D					PID = 0
36			59/4	along fractures;	(CL)						color change 36'6" =	
37											↓	
				T.D. 36'6"							Green 2.5/10G	
				Set well at ≅ 35' bgs								
				Screen 20-35								
				0.010" screen								

Versar Inc.

WELL CONSTRUCTION DIAGRAM
Above–Ground

Location ID: 11 MW 16	Project Name: BFAB Site 11	Project #: 11837.1837.002
Construction Date: 6/22/10	Drilling Method: Hollow Stem	Casing/Screen Material: PVC
Geologist: CWP	Checked By: NGlenn	Date: 6/22/10



COMMENTS: well set 2' X 2' concrete pad for well + set 3 bollards to secure stickup
Bollards set 3' 6" from stickup location.

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Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW01	DATE: 3/19/09

DEPTH TO BOTTOM (INITIAL) 27.26

(FINAL)

STATIC WATER LEVEL (INITIAL) 12.9

(FINAL)

MEASURING POINT TOC

CASING I.D. ~~1"~~ 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/19/09

PUMP (TYPE) ~~Tsunami or cyclone (100')~~ (rated to) mini monsoon

RATE

BAILER (TYPE) SS - 1 1/2" x 3', ~~Tsunami or cyclone pump~~

VOLUME

sat. thickness: 14.36 well vol: 2.34

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C/F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1100	0	7.25	3.628	13.69	high	110.5	lt. brown, murky
1115	2.5	7.08	3.632	12.86	"	4.65	brown, v. murky
1130	5	7.05	3.823	12.83	"	23.23	"
1140	7.5	7.04	3.863	12.11	"	94.39	"
1150	10	7.07	3.893	12.96	"	89.22	"
1200	12.5	7.06	3.951	12.90	"	1223	"
1310	22.5	7.30	4.054	14.26	"	888.3	" Sample from close to surface of H_2O
1320	32.5	7.07	3.963	13.00	"	1100	"
1325	40.0	7.07	4.006	13.22	"	1100	lt. brn, murky
1330	50.0	7.07	3.973	13.24	"	958.7	lt. brn, murky

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW02	DATE: 3/19/08

DEPTH TO BOTTOM (INITIAL) 15.55

(FINAL)

STATIC WATER LEVEL (INITIAL) 10.98

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/19/08

PUMP (TYPE)

RATE

BAILER (TYPE) Stainless Steel 1 1/2" x 3'

VOLUME

sat. thickness: 4.57

well vol. = .74

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0920	0	7.38	3.496	11.7	—	37.61	clear
0925	.75	7.32	3.214	11.41	high	999.7	lt. brown, murky
0930	2	7.23	3.259	11.59	high	993.5	"

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 1MW02 (part II)	DATE: 3/23/09

DEPTH TO BOTTOM (INITIAL) 15.55 (assumed)

(FINAL)

STATIC WATER LEVEL (INITIAL) 10.88

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/23/09

PUMP (TYPE)

RATE

BAILER (TYPE) SS (1 1/2" x 3')

VOLUME

well vol: .74

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
B 1015	0	7.37	3.403	11.41	low-med	1100	lt brown, murky
1018	.75	7.29	3.353	11.25	low-med	607.6	"
1019	1.5	7.31	3.387	11.32	low-med	1100	"
1020	2.25	7.30	3.408	11.31	low-med	1020	"

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW03	DATE: 3/18/09

DEPTH TO BOTTOM (INITIAL) 53.89

(FINAL)

STATIC WATER LEVEL (INITIAL) 22.23

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. M.1715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/18/09

PUMP (TYPE)

RATE

BAILER (TYPE) PVC 1½" x 3'

VOLUME

sat. thickness: 31.66' → 5.16 gal. well vol. = 5.16 gal

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp (°C) F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0948	0	8.84	3.366	14.78	High	NA	Murky, brown
1038	5	7.13	3.63	14.48	high	NA	"
1120	10	7.25	3.646	14.65	high	NA	"
1205	15	7.70	3.328	15.23	high	N/A	"

NA - no turbidity meter available

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW03 (Part II)	DATE: 3/23/09

DEPTH TO BOTTOM (INITIAL) assumed 53.89

(FINAL)

STATIC WATER LEVEL (INITIAL) 21.93

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/23/09

PUMP (TYPE) ~~Bladder/Keystone (Smaller)~~

RATE

BAILER (TYPE) SS (1 1/2" x 3')

VOLUME

well vol. = 5.16

	Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp (°C) F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
B	0907	0	7.54	3.680	13.48	low-med	381.1	gray, murky
	0920	5.0	7.43	3.653	12.6	~~low~~ med	179.9	gray, murky, clouder than above
	0943	10	7.45	3.734	13.07	med	8.44	gray murky, clouder than above
	0954	14	7.54	3.576	13.02	med	420.9	gray, murky

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW04	DATE: 3/19/09

DEPTH TO BOTTOM (INITIAL) 36.49

(FINAL)

STATIC WATER LEVEL (INITIAL) 35.53

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/19/09

PUMP (TYPE)

RATE

BAILER (TYPE) SS 1 1/2" x 3'

VOLUME

Sat. thickness: .96

well volume: .15

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp (°C) F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
~~[illegible]~~ 1450	0	9.65	4.343	16.81	low	797.4	pale beige
1500	.2	10.63	3.383	15.55	low	531.0	lt. brown
1507	.4	9.5	3.246	15.16	med	1010	lt. brown

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW04 (Part II) | DATE: 3/23/09

DEPTH TO BOTTOM (INITIAL) 36.49 (assumed) | PROJECT NO. 11715.0003

(FINAL) | DATE(S) INSTALLED

STATIC WATER LEVEL (INITIAL) 34.75 | DATE(S) DEVELOPED 3/23/09

(FINAL) | PUMP (TYPE)

MEASURING POINT TOC | RATE

CASING I.D. 2" | BAILER (TYPE) SS (1 1/2" x 3')

HYDROGEOLOGIST D. Roth | VOLUME

Sat. thick: 1.74 | well vol: .29

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1049	0	8.3	3.406	14.01	low	138.1	clear → lt. brown
1051	.25	8.19	3.451	14.17	low-med	883.0	lt. brown, murky
1053	.5	8.36	3.475	13.92	low-med	617.7	"

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW05	DATE: 3/~~14~~ 19/09

DEPTH TO BOTTOM (INITIAL) 41.64 PROJECT NO. 111715.0003

(FINAL) DATE(S) INSTALLED

STATIC WATER LEVEL (INITIAL) 29.54 DATE(S) DEVELOPED 3/19/09

(FINAL) PUMP (TYPE) mini monsoon

MEASURING POINT TOC RATE

CASING I.D. 2" BAILER (TYPE) SS (1½"x3')

HYDROGEOLOGIST D. Roth VOLUME

Sat. thickness: 12.1 well volume: 1.97

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C/F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1550	0	7.6	2.667	16.85	high	800.6	brown - dk brown, murky
~~1540~~ 1600	2	7.35	2.551	16.56	high	.62	"
pump 1610	4	7.28	2.483	16.8	high	.29	"
1618	6	7.02	2.424	16.13	high	0.0	brown, murky
1622	8	7.05	2.526	15.85	high	5.71	"
1626	10	7.06	2.542	15.44	high	3.97	"
1630	12	7.0	2.604	15.14	high	22.78	"
1636	14	6.97	2.657	15.11	high	432.6	brown, murky taken from lower depth
1638	16	7.0	2.599	15.06	high	295.0	"
1642	18	6.94	2.617	15.01	high	338.0	"
1644	20	6.98	2.612	14.96	high	368.3	"

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW06	DATE: 3/20/09

DEPTH TO BOTTOM (INITIAL) 40.16 PROJECT NO. 111715.0003

(FINAL) DATE(S) INSTALLED

STATIC WATER LEVEL (INITIAL) 24.7 DATE(S) DEVELOPED 3/20/09

(FINAL) PUMP (TYPE) ~~tsunami/cyclone~~ mini monsoon, mini typhoon

MEASURING POINT TOC RATE

CASING I.D. 2" BAILER (TYPE) SS (1 1/2" x 3')

HYDROGEOLOGIST D. Roth VOLUME

Sat. thickness: 15.46 well volume: 2.5

	Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
B	1545	0	9.31	1.751	15.23	high	.61	dk greyish brown, v. murky
	1556	2.5	8.08	2.097	14.5	high	12.04	"
↓ pump	1608	5.0	8.50	2.021	14.76	high	128.2	"
	1611	7.5	7.58	2.111	14.29	high	129.4	"
↓ small pump	1622	10	7.46	2.142	14.97	med	912.2	pale yellow (from higher in column due to smaller pump)
	1626	12.5	7.49	2.019	14.42	med	1052	lt. brown/grey
	1632	17.5	7.38	2.106	14.2	med	848.8	"
	1638	22.5	7.25	2.070	14.17	med	892.1	" looks pale yellow in tube
	1643	27.5	7.25	2.095	14.2	med	1009	" "
	1648	32.5	7.2	2.087	14.23	low-med	975.2	" "

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 1MW07	DATE: 3/20/09

DEPTH TO BOTTOM (INITIAL) 33.04

(FINAL)

STATIC WATER LEVEL (INITIAL) 18.96

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/20/09

PUMP (TYPE) ~~Tsunami/Cyclone~~ mini monsoon

RATE

BAILER (TYPE) SS (1½" x 3')

VOLUME

sat. thickness: 14.08 well volume: 2.3

	Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C/F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
B	1340	0	7.5	2.811	13.86	high	0 *	brown, murky
	1351	2.5	7.32	3.093	12.85	high	0 *	"
pump	1404	5	7.22	3.422	13.4	high	0*	"
	1409	7.5	7.17	3.512	12.93	high	0*	"
	1413	10.0	7.12	3.574	12.92	high	.48	"
	1418	15.0	7.34	3.599	13.26	med-high	307.7	" water is a little less murky
	1426	20	7.14	3.645	13.26	med-high	227.9	lt. brown, slightly less murky
	1432	25	7.36	3.631	13.22	med-high	201.6	"
	1440	30	7.19	3.631	13.49	med.	1100	pale yellow

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW08	DATE: 3/20/09

DEPTH TO BOTTOM (INITIAL) 30.49

(FINAL)

STATIC WATER LEVEL (INITIAL) 14.94

(FINAL)

MEASURING POINT TOC

CASING I.D. 2"

HYDROGEOLOGIST D. Roth

PROJECT NO. 111715.0003

DATE(S) INSTALLED

DATE(S) DEVELOPED 3/20/09

PUMP (TYPE) ~~tsunami/cyclone~~ mini monsoon

RATE

BAILER (TYPE) SS. (1 1/2" x 3')

VOLUME

Sat. thickness: 15.55 well volume: 2.53

	Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C/F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
B	0940	0	7.40	2.819	12.41	v. high	0	brown, sludge
	0950	2.5	7.2	3.257	11.45	high	.28	brown, v. murky
Pump	1156	5	7.29	3.580	13.88	high	12.9	brown, murky
	1200	7.5	7.11	3.402	12.64	high	96.21	"
	1202	10.0	7.08	3.423	12.68	high	558.9	"
	1207	15	7.13	3.443	12.68	high	646.1	lt. brown, murky
	1213	20	7.04	3.445	12.86	~~high~~ med	1100	"
	1220	25	7.08	3.450	12.85	med.	1100	lt. brown
	1225	30	7.06	3.467	12.85	med	1100	"
	1230	35	7.09	3.479	12.73	med	1100	yellowish beige

Phase 2

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW009	DATE: 7/16/09

DEPTH TO BOTTOM (INITIAL) 44.90
(FINAL) 44.78
STATIC WATER LEVEL (INITIAL) 29.55
(FINAL) 29.94
MEASURING POINT TOC
CASING I.D. ~~[illegible]~~ 2"
HYDROGEOLOGIST D. Roth

PROJECT NO. 11.1715.0003
DATE(S) INSTALLED 6/29/09
DATE(S) DEVELOPED 7/16/09
PUMP (TYPE) mini typhoon
RATE —
BAILER (TYPE) —
VOLUME —

1 well vol = 2.5 gal 5 well vol. = 12.51 gal

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity * (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0930	0	7.25	3.487	18.84	high	619.5	dk. brn., muddy, murky
0940	5	7.27	3.467	16.34	high	2.89	"
0950	10	7.28	3.478	16.93	high	86.32	"
1000	15	7.29	3.483	16.67	high	16.42	"
1015	20	7.19	3.472	16.90	high	738.3	"
1030	25	7.26	3.383	16.47	"	0.00	"

* results suspect due to high turbidity reading fluctuations w/ no visual changes.

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Phase 2

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW10	DATE: 7/7/09

DEPTH TO BOTTOM (INITIAL) 45.6
(FINAL) 45.59
STATIC WATER LEVEL (INITIAL) 26.31
(FINAL) 26.25
MEASURING POINT TOC
CASING I.D. ~~WA~~ 2"
HYDROGEOLOGIST D. Roth

PROJECT NO. 11.1715.0003
DATE(S) INSTALLED 6/30/09
DATE(S) DEVELOPED 7/7/09
PUMP (TYPE) mini typhoon
RATE —
BAILER (TYPE) —
VOLUME —

1 vol = 3.14 5 well vol = 15.72

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity* (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0840	0	6.96	2.840	16.97	med	1045.0	brown, murky
0845	6.5	6.77	2.701	16.05	med-lo	420.8	lt. brown
0850	13	6.71	2.644	15.95	lo	954.3	lt. brown
0855	19.5	6.73	2.627	15.79	lo	1007.0	"
0900	26	6.73	2.617	15.89	lo	680.9	"
0905	32.5	6.73	2.625	16.0	lo	187.6	"

*results suspect due to high turbidity reading fluctuations w/no visual changes

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Phase 2

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW11	DATE: 7/6/09

DEPTH TO BOTTOM (INITIAL) 46.72
(FINAL) 46.92
STATIC WATER LEVEL (INITIAL) ~~Gee~~ 25.08
(FINAL) 29.06
MEASURING POINT TOC
CASING I.D. ~~WW~~ 2"
HYDROGEOLOGIST D. Roth

PROJECT NO. 11.1715.0003
DATE(S) INSTALLED 7/1/09
DATE(S) DEVELOPED 7/6/09
PUMP (TYPE) mini-typhoon
RATE —
BAILER (TYPE) —
VOLUME —

1 well vol = 3.53 5 well vol = 17.6 gl

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity* (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1127	0	7.02	3.197	19.49	high	1100.0	brown, murky, muddy
1135	7	7.07	3.182	16.13	high	202.4	"
1143	14	7.09	3.166	16.50	high	1100.0	brn., murky
1152	21	6.96	3.179	16.22	mod.	1033.0	"
1200	28	6.93	3.161	16.46	mod	822.6	"
1210	35	7.04	3.130	16.04	low	1029.0	"

*results suspect due to high turbidity reading fluctuations w/no visual changes

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Phase 2

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW012	DATE: 7/2/09

DEPTH TO BOTTOM (INITIAL) 18.94 bTOC
(FINAL) 18.93
STATIC WATER LEVEL (INITIAL) 8.6 bTOC
(FINAL) 8.12
MEASURING POINT TOC
CASING I.D. ~~1/4~~ 2"
HYDROGEOLOGIST D. Roth

PROJECT NO. 11.1715.0003
DATE(S) INSTALLED 6/29/09
DATE(S) DEVELOPED 7/2/09
PUMP (TYPE) mini typhoon
RATE —
BAILER (TYPE) —
VOLUME —

1 well volume: 1.69 5 well vol. = 8.43

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU) (results cannot be trusted - due to high turbidity fluctuations w/ no visual changes)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0945	0	6.95	2.739	16.18		695.8	brown, muddy/murky
0948	1.75	6.88	2.788	15.17		0.158	"
0953	3.5	6.88	2.816	15.00		9.75	"
1000	5.25	6.89	2.848	14.50		45.94	"
1003	7.0	6.90	2.866	15.0		22.83	"
1010	8.75	6.91	2.855	14.75		80.94	"
1015	10.5	6.87	2.819	14.28		50.37	slightly lighter brown, murky
1037	14	6.99	2.830	14.45		158.7	
1045	17.5	6.96	2.821	14.46		101.5	

Phase 2

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW13	DATE: 7/6/09

DEPTH TO BOTTOM (INITIAL) 33.48
(FINAL) 33.88
STATIC WATER LEVEL (INITIAL) 17.2
(FINAL) 16.99
MEASURING POINT TOC
CASING I.D. ~~[illegible]~~ 2"
HYDROGEOLOGIST D. Roth

PROJECT NO. 11.1715.0003
DATE(S) INSTALLED 6/30/09
DATE(S) DEVELOPED 7/6/09
PUMP (TYPE) mini typhoon
RATE —
BAILER (TYPE) —
VOLUME —

1 well vol. = 2.65 5 well vol. = 13.27

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity* (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1420	0	7.14	2.736	17.05	high	575.7	brown, murky
1425	5.5 ~~[illegible]~~	6.92	2.446	14.4	high	993.9	"
1430	11 ~~[illegible]~~	6.91	2.445	13.74	high	1100	lt. brn., murky
1435	16.5	6.85	2.436	15.0	high	513.2	"
1440	22	6.93	2.419	14.78	high	624.9	"
1445	28.5	6.85	2.465	15.04	high	114.0	"

* results suspect due to high turbidity reading fluctuations w/no visual changes

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Versar INC.

WELL DEVELOPMENT DATA

LOCID: ~~11MW04~~ 11MW14 ptw 6/23/10	DATE: 06/23/10

DEPTH TO BOTTOM (INITIAL) 20.35 PROJECT NO. SITE 11

(FINAL) 20.35 DATE(S) INSTALLED 5/27/10

STATIC WATER LEVEL (INITIAL) 17.72 DATE(S) DEVELOPED 6/23/10

(FINAL) Dry - long Recovery PUMP (TYPE) MINI TYPHOON

MEASURING POINT TOC - NORTH SIDE RATE ~ 2

CASING I.D. 2" BAILER (TYPE) Disposable Poly Ethylene

HYDROGEOLOGIST Trent Watne VOLUME 1 Liter

saturated thickness 2.65 Ft.

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
0900	initial	7.15	3032	11.87	none	8.5	Clear - pre surge
0905	.25	7.17	1569	13.51	none	445	Cloudy. purged well Dry with Bailer
							Allow Recharge. to 90% Recovery.
	Return 6/29/10 for further Development. WL 19.60 TD 20.35 Thickness .75'						
1042	100 mL	7.25	3458	14.35	none	115	clear - surged well purged Dry.

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW15	DATE: 6/25/10

DEPTH TO BOTTOM (INITIAL) 37.08 / (FINAL) 37.20

STATIC WATER LEVEL (INITIAL) 33.70 (FINAL)

MEASURING POINT BTOC - North Side

CASING I.D. 2"

HYDROGEOLOGIST Trent Wahne

PROJECT NO. Site 11 A1

DATE(S) INSTALLED 6/21/10

DATE(S) DEVELOPED 6/25/10

PUMP (TYPE) NA

RATE NA

BAILER (TYPE) Poly Ethylene - Disposable

VOLUME 1 LITER

Saturated Thickness 3.38 FT 6/29/10 Saturated thickness

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1315	initial	6.67	3567	16.97	low	792	Cloudy - Brown - 3.38' water will surge and
1328	2 Liters	6.52	3658	15.47	low	1209	perform first ~~Bailing~~ Dewatering - Solid bottom - low sediment
1330	1 gal	6.54	3634	15.4	low	1278	Dewaters, ~~but~~ allow recharge and Track recovery.
	Return 6/29/10 for further Development.						2min = .40ft
0930	1	6.85	3668	16.54	none	134	Clear
0940	2	6.96	3749	15.82	none	298	light tan - clear - cloudy
0950	3	6.96	3748	15.60	—	210	0950 Recovery ~~.30~~ .50 = .5/hr Dry

-28843

Versar INC.

WELL DEVELOPMENT DATA

LOCID: 11MW16	DATE: 6/23/10

DEPTH TO BOTTOM (INITIAL) ~~38.90~~ 37.90
(FINAL) 38.0
STATIC WATER LEVEL (INITIAL) 20.50
(FINAL) 20.55
MEASURING POINT TOC
CASING I.D. 2"
HYDROGEOLOGIST Trinitwater

PROJECT NO. Site 11 RI
DATE(S) INSTALLED 6/22/10
DATE(S) DEVELOPED 6/23/10
PUMP (TYPE) Mini Typhoon
RATE 2.5 gpm
BAILER (TYPE) Poly- Disposable
VOLUME 1 Liter

purge 19 gallons / WBV x 5 WBV = 95 gallons

Time	Gallons of Water Removed	pH	Specific Cond. (mS/cm)	Temp °C / F	Sand Content	Turbidity (NTU)	Other Physical Characteristics (Clarity, Odor, Particulates, Color)
1105	initial	7.15	1982	15.60	low/med	1260	Cloudy, brown, tan Bail
1115	2	6.94	2024	14.37	low/med	1279	Cloudy, brown, tan. Bail
1145	5	7.11	2001	14.79	High	1286	" Bail
1208	20	6.86	2057	14.38	low	797	light gray pump.
1220	40	6.90	2159	14.21	none	403	Cloudy, clearing light gray. let pump REST
1240	60	6.90	2679	14.03	none	1279	Cloudy, tan Let pump Rest
1305	80	7.0	2400	14.15	none	1280 ~~2400~~	Clearing - light gray.
1315 ~~1325~~	95	7.0	2358	14.25	none	~~25.~~ 35.3	Clear.

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
1011MW04	6/24/10 ~~6/23/10~~	~~0705~~ 0740	PTW ICWP	BAFB Site 11

Casing Diameter: 2 in.	Casing Stickup: ~~3.~~ 3.17 ft.	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
Total Well Depth: 60.75 ft-btoc	Screened Interval: Assume 10' 61-51 ft-btoc	QED	FC5000
		(Bailer) Poly	YSI 556
		Other	(Other) YSI 9620
Initial Water Level: 27.56 ft-btoc	Top of Filter Pack: 49 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 33.19 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		(Bailer) Poly	Hach
Final Water Level: 56.52 ft-btoc	Sample Depth Range: 56-60 ft-btoc	Other	(Other) YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0745	initial	7.8	15.16	2.689	1.17 11.8%	132	149	clear
0755	5	7.7	14.7	3.310	2.4 24%	115	244	cloudy, light tan
0815	11	7.65	14.7	3.363	1.76 17.4%	130	598	"
0830	16	7.65	15.09	3.358	1.86 18%	145	514	"

Wetted Casing Volume (2-inch diam) = (H) x 0.163 = 5.4 Gallons 16	Full Sample Suite Obtained 3 vocs 8260 VOCs @0835	Condition of Well, Remarks: obstruction well at 3' - cleared out 5/8" tubing
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: (D) C B A Respiratory: (D) C B A	Metals Sample(s) filtered	Checked by: N Glen Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
1011MW07	3/24/09	0840	DR, CP	1011MW07

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
42.88 ft-btoc	28-43 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
27.57 ft-btoc	26 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 15.31 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		
ft-btoc	well vol: 2.5 ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
0842	0	6.97	12.43	3.508	4.07	35.0	111.4	lt. brown - pale yellow
0849	2.5	6.97	13.27	3.432	2.45	47.7	600.7	"
0854	5	6.92	13.67	3.434	1.62	69.0	775.6	"
0900	7.5	6.88	13.84	3.415	1.51	80.0	952.3	lt. brown

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
nothing to note	VOC x 3 vials, 1,4 dioxane x 2 amber glass	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date: 4/15/09

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
1011mw07	6/23/10	1625	CWP / PTW	Site 11 BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3.06 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer Poly	YSI 556
42.75 ft-btoc	43-33 ft-btoc	Other ~~YSI 6920~~	Other 6920
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
26.47 ft-btoc	31 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer Poly	Hach
(H)=16.28 ft.	(F)= 12 ft.	Other	Other YSI 6920
Final Water Level:	**Sample Depth Range:**		
35.61 ft-btoc	35-42 ft-btoc		

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1635	initial	6.86	15.11	3.580	1.81 18%	162	105	cloudy
1640	2.6	6.71	14.70	3.421	1.52 15%	178	224	cloudy
1646	5.2	6.77	14.8	3.549	1.56 16%	145	553	cloudy
1652	7.8	6.72	15.0	3.526	1.47 15%	159	381	cloudy/clear

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.6 Gallons 8 gal	3 VOAs	Good well
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature [signature]	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: [signature]
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: [signature]
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW01	3/23/09	1122	D.R, CP	BAFB-Site 11

Casing Diameter: 2 in.	Casing Stickup: 3 ft.	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
Total Well Depth: 27.50 ~~24.20~~ ft-btoc	Screened Interval: 17-27 ft-btoc	QED	FC5000
Initial Water Level: 12.77 ft-btoc	Top of Filter Pack: 15 ~~12~~ ft-btoc	Bailer	YSI 556
Saturated Thickness: (H)= 14.73 ft.	Filter Pack Thickness: (F)= 2 ft.	Other	Other
Final Water Level: ft-btoc	Sample Depth Range: well vol. = 24 ft-btoc	Sample Equipment:	Turbidity meter
		QED	Lamotte
		Bailer	Hach
		Other	Other Micro TPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1130	0	7.35	12.15	3.955	8.20	109.8	55.7	clear
1140	2.5	7.18	11.54	3.969	2.59	128.0	889.7	lt. brown
1150	5	7.29	11.59	3.982	3.03	171.2	946.5	"
1157	7.5	7.35	11.67	3.972	3.56	180.0	1100	"

H&S Comments: PID(3/19/09): 1.1	Full Sample Suite Obtained: VOC x 3 vials	Condition of Well, Remarks: good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle) MS x 3 vials MSD x 3 vials	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW01	7/7/09	1310	DR, CP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 27.50 ft-btoc	Screened Interval: 17-27 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 10.92 ft-btoc	Top of Filter Pack: 15 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 16.58 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	Sample Depth Range: — ft-btoc	Other	Other Micro TPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1320	0	6.93	17.65	4.118	3.19	107.8	28.18	Clear
1328	2.75	6.97	15.33	4.074	1.92	74.4	197.2	brown, murky
1335	5.5	6.96	15.34	4.061	2.16	63.6	1057	"
1343	8.25	6.93	15.36	4.006	2.04	51.3	1100	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 × VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: N Glenn Date: 9/1/09

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW01	6/24/10	1110	PTW CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3.30 ft.	QED	FC5000
Total Well Depth: 27.49 ft-btoc	Screened Interval: Assume 10' 27-17 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 11.64 ft-btoc	Top of Filter Pack: 15 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 15.8 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 11.65 ft-btoc	Sample Depth Range: 11-27 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1118	initial	7.57	13.00	4.013	2.26 21	137	412	Cloudy Gray
1122	2.5	6.92	12.36	4.032	3.16 30	171	415	Cloudy Gray
1127	5.0	6.91	12.43	4.050	2.6 25.5	187	540	Cloudy Gray
1135	2.5	6.95	12.51	3.998	2.81 28	208	1273	Cloudy Gray

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.5 Gallons 7.7 (8)	VOCs @ 1140	Good well - Produces good water. QC MS/MSD
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
HMW02	3/24/09	1100	DR, CP	BAFB Site 11

Casing Diameter: 2 in.	Casing Stickup: ~~[illegible]~~ -0.5 ft.	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
Total Well Depth: 15.65 ~~[illegible]~~ ft-btoc	Screened Interval: 7.5-15.5 ft-btoc	QED Bailer Other	FC5000 YSI 556 Other
Initial Water Level: 10.99 ft-btoc	Top of Filter Pack: 6 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 4.66 ft.	Filter Pack Thickness: (F)= 1.5 ft.	QED Bailer	Lamotte Hach
Final Water Level: ft-btoc	Sample Depth Range: well vol. .76 ft-btoc	Other	Other MicroTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1115	0	7.33	11.45	3.417	6.92	165.7	1100	H. brown - pale yellow
1120	.75	7.3	10.86	3.372	7.16	158.8	377.6	"
1123	1.5	7.3	11.02	3.401	6.94	147.3	1100	"
1128	2.5	7.35	11.49	3.421	6.75	137.3	1100	"

H&S Comments: PID(3/19/09): 6.0	Full Sample Suite Obtained: VOC x 3 vials	Condition of Well, Remarks: good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Samplers Signature: Deborah Roth
Protective Level Dermal: D C B A Respirator: D C B A	Metals Sample(s) filtered	Checked by: N Glenn Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW02	7/7/09	1215	DR, CP	BAAB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	-0.5 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
15.65 ft-btoc	7.5-15.5 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
9.32 ft-btoc	6 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 6.33 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		MICRO TPH
— ft-btoc	— ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1223	0	7.01	17.24	2.252	3.467	73.8	885.3	lt. brn/yellow
1226	1	7.22	14.75	3.317	2.25	16.1	292.3	"
1230	2	6.99	14.19	3.294	2.41	47.8	277.3	"
1234	3	7.12	14.27	3.358	2.58	32.8	819.0	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 × VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date: 9/1/09

|vol| = 1.03

3vol = 3.09

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW02	6/24/10	1010	MW CWP	Site 11 BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	Flushmount ft.	QED	FC5000
Total Well Depth: 15.59 ft-btoc	Screened Interval: Assume 10' 15.5 - 10.5 ft-btoc	Bailer Poly	YSI 556
		Other Disp.	Other
Initial Water Level: 9.69 ft-btoc	Top of Filter Pack: 8.5 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 5.9 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly	Hach
Final Water Level: 12.65 ft-btoc	Sample Depth Range: 12.65 - 15.69 ft-btoc	Other Disp.	Other

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1015	initial	7.09	13.15	3275	1.55 14.6	71.1	300	cloudy. light Tan
1019	1	6.99	12.98	2965	2.25 21	98	116	cloudy
1021	2	6.91	12.97	2807	2.65 25	110	1236	cloudy
1025	3	6.93	13.01	2975	2.37 23	115	1136	cloudy

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = .96 (1.0) Gallons 3	VOCs @ 1030	well tends to Dewater
H&S Comments:	Partial Sample Suite Obtained	Recharges quickly
	No Sample Obtained	
H&S Signature: [signature]	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: [signature]
Protective Level Dermal: (D) C B A Respiratory: (D) C B A	Metals Sample(s) filtered	Checked by: N Olen Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW03	3/24/09	1000	DR, CP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	~~[illegible]~~ -0.8 ft.	QED	FC5000
Total Well Depth: ~~[illegible]~~ 53.98 ft-btoc	Screened Interval: 34.2 - 54.2 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 35.61 ft-btoc	Top of Filter Pack: 32.2 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 18.37 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	Sample Depth Range: wellvol. = 3 ft-btoc	Other	Other MicroTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
0957	0	7.35	12.13	3.699	7.31	105.5	324.3	lt. brown/gray
1009	3	7.21	12.48	3.840	3.48	133.0	547.0	"
1016	6	7.38	12.77	3.723	3.16	95.1	520.8	"
1030	8 1/2	7.59	12.24	3.528	7.53	167.1	352.6	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID (3/18/09): 7.8	VOC x 3 vials	well dewatered after 8 1/2 gal.
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 4/15/09

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW03	6/24/10	0950	PTW / CWD	BAFB · S.4 N

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	Flush mount ft.	QED	FC5000
Total Well Depth: 53.86 ft-btoc	Screened Interval: Assume 10' 54-44 ft-btoc	Bailer Poly Disp	YSI 556
		Other YSI	Other YSI 9620
Initial Water Level: 19.81 ft-btoc	Top of Filter Pack: 42 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)=34.05 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 52.06 ft-btoc	Sample Depth Range: 52-53.86 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0900	initial	7.28	14.27	1.994	2.54 25%	109	115	Clear
0910	5.5	7.16	14.67	3.500	1.32 13.4	101	232	cloudy TAN
0921	11	7.10	14.17	3.488	1.28 13	110	363	cloudy tan
0935	16.5	7.18	14.10	3.459	1.42 14	106	613	cloudy tan

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 5.5 Gallons 16.5	3 VOCs 100% @ 0940	Good well, large purge volume well dewaters
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW04	3/24/09	1150	DR, CP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 36.58 ~~36.49~~ ft-btoc	Screened Interval: 22 - 37 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 35.39 ft-btoc	Top of Filter Pack: 20 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 1.19 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	Sample Depth Range: well vol.: .19 ft-btoc	Other	Other MicroTPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1202	0	8.75	15.15	3.35	3.00	168.0	674.0	lt brown/gray

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(3/19/09): 3.5	VOC x 3 vials	not enough H_2O to purge
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Green
Respiratory D C B A		Date: 4/15/09

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW04	6/23/16	1545	CWP/PTW	Site 11 BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3.14 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer Poly Disp	YSI 556
36.50 ft-btoc	36-26 ft-btoc	Other	Other YSI 6920
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
20.85 ft-btoc	24 ft-btoc		
Saturated Thickness:	**Filter Pack Thickness:**	QED	Lamotte
(H)= 15.65 ft.	12 (F)= ft.	Bailer Poly Disp	Hach
Final Water Level:	**Sample Depth Range:**	Other	Other YSI 6920
33.20 ft-btoc	33-36 ft-btoc		

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1555	initial	6.61	17.0	3.364	1.47 15.7%	221	370	Cloudy
1605	2.5	6.54	14.8	3.111	1.82 18%	225	146	Clearing.
1610	5	6.72	14.5	2.719	1.85 18%	235	140	Clear
1615	9	6.69	14.6	3.265	1.62 16%	240	123	Clear

Wetted Casing Volume (2-inch diam) = (H) x 0.163 = 2.5 Gallons 7.65	Full Sample Suite Obtained 3 VOAs 8260 VOCs	Condition of Well, Remarks: good well - did not Dewater
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature:	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW005	3/23/09	1450	DR CP	BHFB, Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 41.75 ~~41.64~~ ft-btoc	Screened Interval: 27 - 42 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 29.26 ft-btoc	Top of Filter Pack: 25 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 12.49 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	Sample Depth Range: well vol.: 2.03 ft-btoc	Other	Other microTPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1500	0	~~7.4~~ 7.4	13.78	2.867	7.15	123.0	228.8	grayish brn.
1507	2	7.37	13.65	2.871	3.47	128.4	204.4	"
1510	4	7.03	13.99	2.749	1.53	108.4	954.8	"
1515	6	6.97	13.81	2.726	1.85	98.6	933.9	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(3/19/09): 24.3	VOC x 3 vials	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle) Dup x 3	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glem
Respirator: D C B A		Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW05	7/7/09	0920	DR, CP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
41.75 ft-btoc	27-42 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
27.42 ft-btoc	25 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 14.33 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		MICRO TPH
— ft-btoc	— ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
0935	0	6.81	16.92	2.799	2.73	114.6	976.8	brown, murky
0941	2.34	6.70	15.35	2.635	1.430	116.1	284.8	"
0950	4.68	6.73	15.55	2.683	2.06	113.2	86.17	"
1000	7.0	6.61	17.25	2.569	1.84	123.1	193.0	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle) 3 x Dup VOC	Sampler's Signature: Deborah Roth
Protective Level Dermal D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory D C B A		Date: 9/1/09

1 vol = 2.34

3 vol = 7.0

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW05	6/25/10	1130	PTW/CMP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.80 ft.	QED	FC5000
Total Well Depth: 41.38 ft-btoc	Screened Interval: Assume 10' 41-31 ft-btoc	Bailer Disp. Poly	YSI 556
Initial Water Level: 27.02 ft-btoc	Top of Filter Pack: 29 ft-btoc	Other	Other YSI 9620
Saturated Thickness: (H)= 14.36 ft.	Filter Pack Thickness: (F)= 12 ft.	Sample Equipment: QED	Turbidity meter Lamotte
Final Water Level: 27.15 ft-btoc	Sample Depth Range: 27-41 ft-btoc	Bailer Disp. Poly	Hach
		Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1135	initial	7.2	16.68	2.872	1.9 21	182	277	Cloudy Tan
1140	2.5	6.80	14.85	2.972	2.11 21	227	1287	Cloudy
1145	5.0	6.68	14.62	2.885	1.97 19	263	1166	Cloudy
1151	7.5	6.71	14.83	2.845	2.08 21	269	792	Cloudy
							Decreasing with	
							purging.	

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.3 Gallons 7.0	VOCs Collected @ 1155	Nothing unusual about well - All samples filled w/ 1 Bailer
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	Field Dupe Collected
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW006	3/23/09	1410	DR, CP	BAFB, Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 40.60 ft-btoc	**Screened Interval:** 26-41 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 24.68 ft-btoc	**Top of Filter Pack:** 24 ft-btoc	**Sample Equipment:**	**Turbidity meter**
Saturated Thickness: (H)= 15.92 ft.	**Filter Pack Thickness:** (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	**Sample Depth Range:** well vol: 2.6 ft-btoc	Other	Other micro TPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1416	0	7.25	13.63	2.199	4.33	152.6	765.1	pale yellow
1421	2.5	7.45	13.33	2.131	1.84	156.8	823.1	lt. brn / pale yellow
1427	5	7.37	13.42	2.097	1.65	143.9	936.1	lt. brn
1433	7.8	7.35	13.36	2.088	1.97	133.4	100.2	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(3/20/09): 5.7	VOC x3 vials	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Alem
Respiratory D C B A		Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW06	7/7/09	1440	DR, CP	BAFB-Site D

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 40.60 ft-btoc	**Screened Interval:** 26-41 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 22.49 ft-btoc	**Top of Filter Pack:** 24 ft-btoc	**Sample Equipment:**	**Turbidity meter**
Saturated Thickness: (H)= 18.11 ft.	**Filter Pack Thickness:** (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	**Sample Depth Range:** — ft-btoc	Other	Other MICROTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1440	0	7.03	16.53	2.186	0.74	58.9	18.07	clear
1450	3	7.12	15.80	2.148	0.96	71.0	977.7	brown murky
1500	6	7.02	15.32	2.136	0.54	64.2	431.3	yellowish brn.
1512	9	7.10	17.11	2.266	2.24	62.1	863.1	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 9/1/09

1 vol = 2.95

3 vol = 8.8

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW06	6/24/10	1300	PTW / CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.89 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:** assume 10'	Bailer Poly Dispos.	YSI 556
40.43 ft-btoc	40-30 ft-btoc	Other	Other YSI 9620
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
22.68 ft-btoc	32 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer Poly Dispos.	Hach
(H)= 17.75 ft.	(F)= 12 ft.	Other	Other YSI 9620
Final Water Level:	**Sample Depth Range:**		
22.96 ft-btoc	~~40~~ 20-40 ft-btoc		

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1300	initial	6.96	15.23	2245	1.78 17	205	1086	Cloudy
1315	3	6.74	14.69	2174	2.18 21	263	33.6	Cloudy
1323	6	6.6	15.00	2168	1.30 13	313	473	Cloudy.
1330	9	6.5	14.85	2186	1.56 15	346	348	Cloudy

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.89(3) Gallons(9)	8260 VOCs @ 1335	Good well
	Partial Sample Suite Obtained	produces well
H&S Comments:	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW07	3/23/09	1320	DR, CP	BAFB, Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
33.41 ft-btoc	18-33 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
18.94 ft-btoc	16 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)=14.47 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		Micro TPW
ft-btoc	well vol: 2.4 ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1328	0	7.49	12.78	3.626	9.53	196.4	913.8	lt brn - brn
1342	2.5	7.21	12.65	3.623	3.92	167.1	893.6	"
1347	5	7.35	12.47	3.640	4.06	185.5	961.7	"
1352	7.5	7.44	12.36	3.654	4.37	206.1	780.4	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(3/20/09): 2	VOC x 3 vials	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW07	7/8/09	0850	DR, CP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: 33.41 ft-btoc	Screened Interval: 18-33 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 16.65 ft-btoc	Top of Filter Pack: 16 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 16.76 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	Sample Depth Range: — ft-btoc	Other	Other MICROTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
0915	0	7.05	16.33	3.626	3.50	135.5	5.15	lt. brn, yellow, slightly murky
0922	2.75	7.03	13.86	4.3644	4.21	127.9	1100.0	"
0928	5.5	7.01	14.78	3.630	3.85	122.6	1049.0	"
0937	8.25	7.00	14.16	3.611	4.17	121.4	685.0	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Green
Respirator: D C B A		Date: 9/1/09

1 vol: 2.73

3 vol: 8.19

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW07	6/24/10	1350	PTW / CWP	BAF13 Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3.20 ft.	QED	FC5000
Total Well Depth: 33.26 ft-btoc	Screened Interval: assume 10' 33-23 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 16.66 ft-btoc	Top of Filter Pack: 21 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 16.6 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 16.67 ft-btoc	Sample Depth Range: 16-33 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1400	initial	6.66	13.87	3.648	1.0 9.9	195	60	Cloudy / Clear
1402	2.7	6.5	13.51	3.696	5.0 48	278	200	Cloudy.
1408	5.4	6.2	13.10	3.714	4.25 43	363	673	Cloudy
1413	8.0	6.16	13.42	3.689	4.16 43	407	147	Cloudy

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.7 Gallons 8	— VOCs @ 1415	Good well 1250 ounces 9000 water
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: N Allen Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW08	3/23/09	1240	DR CP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth: ~~30.44~~ 30.88 ft-btoc	Screened Interval: 16-31 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 14.91 ft-btoc	Top of Filter Pack: 14 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 15.97 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	Sample Depth Range: well vol.: 2.6 ft-btoc	Other	Other MicroTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1250	0	7.32	12.95	3.500	3.42	226.7	1100	lt. brown - brown
1255	2.5	7.20	12.06	3.486	2.98	231.1	180.7	"
1305	5	7.38	11.86	3.488	3.18	245.1	137.3	"
1308	~~7.5~~ 5	7.2	11.9	3.467	2.77	229.6	413.4	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(3/22/09): 1.7	VOC x3 vials	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Samplers Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 4/15/09

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW08	7/7/09	1400	DR, CP	BHFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
30.88 ft-btoc	16-31 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
12.70 ft-btoc	14 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 18.18 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		MicroTPW
— ft-btoc	— ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1401	0	7.02	18.04	3.598	2.65	77.7	643.7	
1411	3	7.0	15.5	3.455	2.29	65.4	625.2	
1420	6	7.03	15.85	3.598	2.82	95.2	201.6	
1426	9	7.01	15.71	3.463	2.36	72.3	310.4	

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: (D) C B A	Metals Sample(s) filtered	Checked by: N Olenn
Respirator: (D) C B A		Date: 9/1/09

1 vol = 2.96

3 vol = 8.89

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW08	6/24/10	12.05	PTN CWP	BAFB - Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	13.15 ft.	QED	FC5000
Total Well Depth: 30.50 ft-btoc	Screened Interval: assume 10' 30-20 ft-btoc	Bailer Disp. Bailer	YSI 556
		Other	Other YSI 9620
Initial Water Level: 13.17 ft-btoc	Top of Filter Pack: @ 18 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 17.3 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 13.13 ft-btoc	Sample Depth Range: 13-30 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1214	initial	6.8	13.92	3.175	2.36 23	155	1280	Cloudy clear
1220	2.8	6.8	13.78	3.065	1.88 18	243	1222	Cloudy
1224	5.6	6.5	12.78	3.202	2.6 25	263	1266	Cloudy
1230	8.5	6.6	12.64	3.070	2.9 28	291	1265	cloudy

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.8 Gallons 8.5	VOCs 8260 @ 1235	Good well
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal D C B A	Metals Sample(s) filtered	Checked by:
Respiratory D C B A		Date:

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW09	7/7/09	1024	DR, CP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.7 ft.	QED	FC5000
Total Well Depth: 44.78 ft-btoc	Screened Interval: ~~27-42~~ 29.7-44.7 ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 29.94 ft-btoc	Top of Filter Pack: ~~25~~ 27.7 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 14.84 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	Sample Depth Range: — ft-btoc	Other	Other MICROTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1035	0	7.25	20.2	3.523	1.13	13.0	105.7	brownish gray, murky
1045	2.5	7.15	17.88	3.537	0.32	-11.4	0.0	"
1100	5	7.28	20.55	3.551	0.37	-26.6	4.18	"
1115	7.5	7.20	21.7	3.517	1.06	-17.5	0.68	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID (7/6/09): 0	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle) 3 x MS, VOC; 3 x MSD, VOC	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A (B circled)	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date: 9/1/09

1 vol = 2.4
3 vol = 7.25

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11mw09	6/25/10	1005	PTW / CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.7 ft.	QED	FC5000
Total Well Depth: 44.49 ft-btoc	Screened Interval: assume 10' 44-34 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 29.49 ft-btoc	Top of Filter Pack: 32 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 15 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 36.93 ft-btoc	Sample Depth Range: 36.93 - 44.49 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1010	initial	7.47	15.01	3.556	4.4 44	150	1090	Cloudy Gray
1015	2.5	7.37	15.06	3.582	3.4 35	178	1280	Cloudy Gray
1021	5.0	7.21	15.41	3.579	3.37 34	185	1293	Cloudy Gray
1026	7.5	7.22	15.02	3.575	2.78 28	214	1286	Cloudy Gray

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.5 Gallons 7.5	— VOCs @ 1030	very turbid - lots of sediment in well.
H&S Comments:	Partial Sample Suite Obtained 3 vials	
	No Sample Obtained	
H&S Signature:	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: Date:

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW10	7/8/09	1050	DR, CP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	-.56 ft.	QED	FC5000
Total Well Depth: 45.59 ft-btoc	Screened Interval: 30.44 – 45.44 ~~31-46~~ ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 26.25 ft-btoc	Top of Filter Pack: ~~29~~ 28.44 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 19.34 ft.	Filter Pack Thickness: (F)= ~~NA~~ 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	Sample Depth Range: — ft-btoc	Other	Other MICROTPW

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
—	0	—	—	—	~~[illegible]~~ —	~~[illegible]~~	785.3	brn, murky
1110	3.25	6.89	16.82	2.726	0.81	39.8	679.2	"
1121	6.5	6.85	17.68	2.682	1.02	37.8	1020.0	"
1131	9.75	6.89	17.77	2.701	1.50	29.6	671.0	

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(7/7/09): 0	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Olsen
Respirator: D C B A		Date: 9/1/09

1 vol: 3.15

3 vol: 9.45

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW10	6/25/10	1205	PTW CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	Flushmount - 0.4 ft.	QED	FC5000
Total Well Depth: 45.59 ft-btoc	Screened Interval: Assume 10' 45-35 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 25.91 ft-btoc	Top of Filter Pack: 33 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)=19.68 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp	Hach
Final Water Level: 25.87 ft-btoc	Sample Depth Range: 25-45 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1211	initial	7.03	17.49	2.881	~~8.8~~ 1.2 PTW 13 ~~94~~	198	18.9	Clear
1216	3	6.58	15.6	2.917	1.83 18	267	1271	Cloudy. Tan/Orange
1224	6	6.55	15.6	2.793	1.54 16	337	310	Cloudy
1238	9.6	6.53	15.6	2.791	1.32 13	342	102	Cloudy Clearing

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 3.2 Gallons 9.6	VOCs @ 1240	Good well, produces good water.
H&S Comments:	Partial Sample Suite Obtained: 3 vials	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW11	7/8/09	0955	DR, CP	BAFB - Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.84 ft.	QED	FC5000
Total Well Depth: 46.92 ft-btoc	Screened Interval: 32.84 - 47.84 ~~30-45~~ ft-btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 29.06 ft-btoc	Top of Filter Pack: 30.84 ~~28~~ ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 17.86 ft.	Filter Pack Thickness: (F)= ~~3~~ 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: ft-btoc	Sample Depth Range: — ft-btoc	Other	Other MICROTPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1005	0	7.04	17.62	3.122	~~[illegible]~~ 4.07	140.1	221.1	clear ~~[illegible]~~ yellow ~~[illegible]~~
1020	3	7.14	16.53	3.145	4.16	138.0	0.62	brn. murky, muddy
1028	6	7.08	17.92	3.185	3.03	108.3	122.4	"
1041	9	7.02	16.24	3.118	2.97	117.4	274.5	brn, murky

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(7/6/09): 0	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respiratory: D C B A		Date: 9/1/09

1 vol = 2.91

3 vol = 8.73

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW11	6/25/10	1045	PTW / CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.75 ft.	QED	FC5000
Total Well Depth: 46.68 ft-btoc	Screened Interval: Assume 10' 46 - 56 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 29.15 ft-btoc	Top of Filter Pack: 54 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 17.53 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 32.0 ft-btoc	Sample Depth Range: 32 - 46 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1055	initial	7.50	15.04	2.887	5.47 54.15	173	257	Cloudy light Tan
1100	3	7.28	14.5	2.975	4.47 45	207	1285	highly Turbid
1107	6	7.21	14.92	2.965	4.01 40	227	1288	Cloudy gray/Tan
1117	9	7.20	14.88	2.916	4.43 45	232	1275	Cloudy gray/Tan

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.85 (3) Gallons (9)	VOCs @ 1120	VERY Turbid water high Sediment.
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: Date:

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW012	7/6/09	1245	DR	Site 11-BAHB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	-.65 ft.	QED	FC5000
Total Well Depth: ~~8.34~~ 18.93 ft-btoc	Screened Interval: ~~9-19~~ 8.35-18.35 ~~ft-btoc~~ ~~bgs~~ btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 8.34 ft-btoc	Top of Filter Pack: ~~7~~ 6.35 ~~ft-btoc~~ ~~bgs~~ btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 10.59 ft.	Filter Pack Thickness: (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	Sample Depth Range: — ft-btoc	Other	Other Micro TPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1300	0	6.93	17.47	3.033	1.83	95.0	139.8	brown, murky
1307	1.75	6.83	15.77	2.919	1.47	85.5	401.9	"
1315	3.50	6.86	15.44	2.902	1.73	91.8	232.2	"
1320	5.25	6.82	15.44	2.912	1.64	96.9	197.1	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID (7/2/09): 0	3x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date: 9/1/09

1 vol. = 1.73
3 vol = 5.18

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW12	7/7/09	1245	DR, CP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	-0.65 ft.	QED	FC5000
Total Well Depth: 18.93 ft-btoc	**Screened Interval:** 8.35 - 18.35 ~~9-19~~ ft-~~btocd~~ btoc	Bailer	YSI 556
		Other	Other
Initial Water Level: 8.12 ft-btoc	**Top of Filter Pack:** 6.35 ~~7~~ ft-~~btoc~~ btoc	**Sample Equipment:**	**Turbidity meter**
Saturated Thickness: (H)= 10.81 ft.	**Filter Pack Thickness:** (F)= 2 ft.	QED	Lamotte
		Bailer	Hach
Final Water Level: — ft-btoc	**Sample Depth Range:** — ft-btoc	Other	Other MicroTPH

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
1250	0	6.92	15.94	2.947	1.36	65.1	203.3	brn, murky
1255	1.75	6.91	14.38	2.919	1.42	49.0	462.9	"
1300	3.5	6.95	14.54	2.931	2.47	46.9	276.9	"
1305	5.25	6.95	14.99	2.920	1.69	38.4	523.5	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(7/2/09): 0	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date: 9/1/09

1 vol = 1.76

3 vol = 5.30

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW12	8/5/09	1240	DR	Site 11-BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	-.65 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI ~~556~~ 6920
18.94 ft-btoc	8.35-18.35 ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
8.67 ft-btoc	6.35 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 10.27 ft.	(F)= 2 ft.	Other	Other YSI 6920
Final Water Level:	**Sample Depth Range:**		
— ft-btoc	— ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
12:56	0 ~~0.25~~	6.98	20.55	2.883	1.93	95.3	1140.8	
13:05	1.75 ~~0.50~~	6.97	18.37	2.918	1.78	87.5	1697.1	
13:13	3.25 ~~0.75~~	6.94	16.65	2.947	1.62	107.4	2126.4	
1325	5.25	6.96	18.16	2.944	1.86	80.7	486.7	

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
none	2 x 1,4 DIOXANE	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle) 2 x 1,4 Dioxane (MS) 2 x 1,4 Dioxane (MSD)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: N Glenn
Respirator: D C B A		Date:

1 vol = 1.67

3 vol = 5.02

Versar INC

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW12	6/24/10	1040	JTW CWP	BAFB-Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	Flushmount ft.	QED	FC5000
Total Well Depth: 18.94 ft-btoc	Screened Interval: 19-9 ft-btoc	Bailer Poly Disp	YSI 556
		Other	Other YSI 9620
Initial Water Level: 8.64 ft-btoc	Top of Filter Pack: 7 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 10 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 8.65 ft-btoc	Sample Depth Range: 8.6-18.94 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1045	Initial	6.96	14.00	1.671	2.46 23	173	992	Cloudy Tan
1047	1.6	6.94	12.97	3.134	2.43 24	178	1270	cloudy
1051	3.2	6.92	13.10	3.108	1.80 18	192	1273	Cloudy
1057	4.8	6.92	13.6	3.136	2.13 20	201	1275	Cloudy

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 1.6 Gallons 5.0	VOCs @ 1100	Good well - produces well
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Phase 2

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW13	7/8/09	0815	DR, CP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.97 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
33.88 ft-btoc	18.97-33.97 ~~16-31~~ ft-btoc	Other	Other
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
16.99 ft-btoc	~~14~~ 16.97 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer	Hach
(H)= 16.89 ft.	(F)= 2 ft.	Other	Other
Final Water Level:	**Sample Depth Range:**		MicroTPW
— ft-btoc	— ft-btoc		

Time	Gallons Removed	pH	Temprature °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Discriptions
0825	0	6.96	14.84	2.421	0.95	67.2	148.0	brown, murky
0830	2.75	6.84	15.06	2.461	1.58	87.8	214.3	"
0837	5.5	6.82	14.69	2.456	1.64	93.0	291.0	"
0845	8.25	6.87	15.03	2.432	1.32	96.4	97.81	"

H&S Comments:	Full Sample Suite Obtained	Condition of Well, Remarks
PID(7/6/09): 0	3 x VOC	good
	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: Deborah Roth	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: Deborah Roth
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW13	6/25/10	0830	CWP / PTW	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	3.0 ft.	QED	FC5000
Total Well Depth: 33.86 ft-btoc	Screened Interval: Assume 10' 34-324 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 17.44 ft-btoc	Top of Filter Pack: 22 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)=16.42 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp.	Hach
Final Water Level: 17.50 ft-btoc	Sample Depth Range: 17-33 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0837	initial	7.38	13.28	2396	2.0 19	130	17.7	clear
0840	2.6	7.31	12.57	2497	2.49 23	149	1265	Cloudy, Tan
0846	5.2	7.18	12.81	2399	1.51 14	151	1267	Cloudy, Tan
0852	7.8	7.18	12.66	2415	1.71 16	156	1266	Cloudy, Tan

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2.63 Gallons 8	3 VOAs VOCs @ 0855	Good well. Produces well
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
MW14 ~~MW014~~	7/8/10	0830	PTW	BAFB (Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.0 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:** assume 10'	Bailer Poly Disp.	YSI 556
20.35 ft-btoc	20-10 ft-btoc	Other	Other YSI 9620
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
18.76 ft-btoc	8 ft-btoc	QED	Lamotte
Saturated Thickness:	**Filter Pack Thickness:**	Bailer Poly Disp	Hach
(H)= 1.59 ft.	(F)= 12 ft.	Other	Other YSI 9620
Final Water Level:	**Sample Depth Range:**		
19.96 ~~19.86~~ ft-btoc	19.96 ~~19.86~~ -20.35 ft-btoc		

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0840	.25	7.10	13.8	3110	8.75 86	197	18.6	clear
			collected sample- well			dry	after	.25 gallons
			purged.					

Wetted Casing Volume (2-inch diam) = (H) x 0.163 = .25 Gallons .77	Full Sample Suite Obtained 0850	Condition of Well, Remarks:
H&S Comments:	Partial Sample Suite Obtained	poor producing well. Several days for recovery.
	No Sample Obtained	
H&S Signature:	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A Respiratory: D C B A	Metals Sample(s) filtered	Checked by: Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
MMW15 ~~MMW16~~	7/1/10	0930	PTW	Site 11 BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	Flushmount ft.	QED	FC5000
Total Well Depth: 37.20 ft-btoc	Screened Interval: 37.22 ft-btoc	(Bailer) Poly Dispos.	YSI 556
Initial Water Level: 33.28 ft-btoc	Top of Filter Pack: 20 ft-btoc	Other	(Other) YSI 9620
Saturated Thickness: (H)= 3.92 ft.	Filter Pack Thickness: (F)= 12 ft.	Sample Equipment: QED	Turbidity meter Lamotte
Final Water Level: 36.55 ft-btoc	Sample Depth Range: 36.5 – 37.2 ft-btoc	(Bailer) Poly Disp.	Hach
		Other	(Other) YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0955	initial	7.26	16.27	3.525	4.64 48	148	12	Clear
1000	.66	7.28	15.03	3.770	5.3 54	162	48	Clear, Cloudy
1005	1.32	7.31	15.25	3.745	4.64 46	158	62	Clear/Cloudy
1030	1.95	7.26	15.5	3.760	4.47 49	168	42	Clear, Cloudy

Wetted Casing Volume (2-inch diam) = 1.95	Full Sample Suite Obtained VOCs @ 1035	Condition of Well, Remarks:
(H) x 0.163 = .63 Gallons ~~2.0~~	Partial Sample Suite Obtained	well nearly dewatered Does not produce well.
H&S Comments:	No Sample Obtained	
H&S Signature: [signature]	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: [signature]
Protective Level Dermal: (D) C B A Respiratory: (D) C B A	Metals Sample(s) filtered	Checked by: [signature] Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
11MW16	6/25/10	0915	PTW / CWP	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2.0 in.	2.7 ft.	QED	FC5000
Total Well Depth: 38.0 ft-btoc	Screened Interval: 15' 38-23 ft-btoc	Bailer Poly Disp.	YSI 556
		Other	Other YSI 9620
Initial Water Level: 20.953 ~~25.30~~ ft-btoc	Top of Filter Pack: 21 ft-btoc	Sample Equipment:	Turbidity meter
Saturated Thickness: (H)= 17.47 ft.	Filter Pack Thickness: (F)= 12 ft.	QED	Lamotte
		Bailer Poly Disp	Hach
Final Water Level: 20.58 ft-btoc	Sample Depth Range: 20-38 ft-btoc	Other	Other YSI 9620

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)		ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0923	initial	7.2	14.07	2.214	3.02	29.6	153	638	Cloudy light Tan
0930	3	7.1	13.80	2.237	3.49	34	172	1283	Cloudy Tan
0935	6	7.1	13.3	2.204	2.29	23	178	1272	Cloudy Tan
0940	9	7.1	13.3	2.198	2.0	20	179	1273	Cloudy Tan.

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 3 Gallons 9	VOCs @ 0945 FD	Field Duplicate Good Well
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature:	QC Samples: Dup., EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
710MW03	6/23/10	1445	CWP / PTW	BAFB

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
2 in.	2.87 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:**	Bailer	YSI 556
38.27 ft-btoc	38.27 – 28.27 ft-btoc (Assume 10' Screen)	Other	Other YSI 6920
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
25.77 ft-btoc	26.27 ft-btoc		
Saturated Thickness:	**Filter Pack Thickness:**	QED	Lamotte
(H)= 12.5 ft.	(F)= 12 ft.	Bailer	Hach
Final Water Level:	**Sample Depth Range:**	Other	Other
34.5 ft-btoc	34-38 ft-btoc		YSI 6920

Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
1500	initial	6.52	16.16	2.420	1.35 13.7%	161	262	Cloudy, brn.
1505	2	6.42	14.85	2.480	1.9 19.5%	205	1281	Cloudy brown
1508	4	6.35	14.00	2.490	2.58 25.5%	235	1279	Cloudy brn
1515	6	6.38	14.02	2.502	2.32 22.3%	265	194	Cloudy, brn

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.163 = 2 Gallons 6	3 vials VOCs 8260	Did not Dewater
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature: [signature]	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature: [signature]
Protective Level Dermal: D C B A	Metals Sample(s) filtered	Checked by: [signature]
Respiratory: D C B A		Date:

MW12

Versar INC.

GROUNDWATER SAMPLING FIELD DATA SHEET

LOCID:	Date:	Time:	Samplers Initials	Site Location:
LFW-8	6/25/10	0730	CWP / PTW	BAFB Site 11

Casing Diameter:	Casing Stickup:	Purge Equipment	pH/ORP/T°/DO/Cond. Meter
4 in.	1.5 ft.	QED	FC5000
Total Well Depth:	**Screened Interval:** Assume 10'	Bailer Poly Disp	YSI 556
19.40 ft-btoc	19-9 ft-btoc	Other	Other YSI 9620
Initial Water Level:	**Top of Filter Pack:**	**Sample Equipment:**	**Turbidity meter**
11.61 ft-btoc	7 ft-btoc		
Saturated Thickness:	**Filter Pack Thickness:**	QED	Lamotte
(H)= 7.8 ft.	(F)= 12 ft.	Bailer Poly Disp.	Hach
Final Water Level:	**Sample Depth Range:**	Other	Other YSI 9620
11.98 ft-btoc	11.98-19.40 ft-btoc		

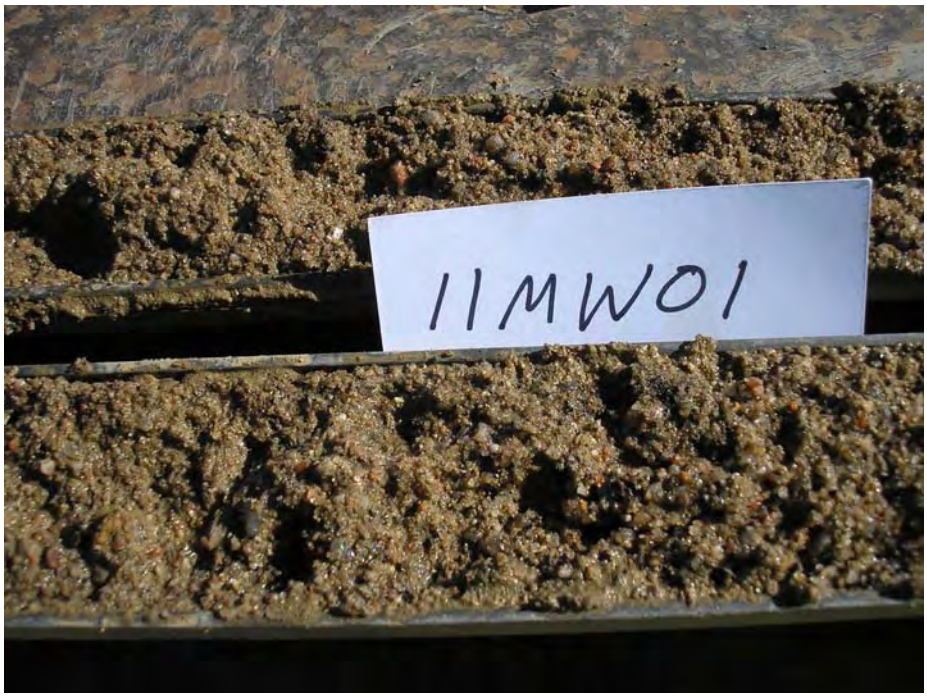
Time	Gallons Removed	pH	Temp °C	Specific Conductance mS/cm	Dissolved Oxygen (mg/L)/(%)	ORP (mV)	Turbidity (NTU)	Visual Comments, Descriptions
0740	initial	7.43	11.50	3.809	3.80 37	129	8.2	clear
0745	5	7.21	11.04	3.825	3.32 28	146	29	Clear
0755	10	7.16	11.00	3.812	2.1 19	161	27	clear
0800	15	7.18	10.90	3.822	2.4 20	163	32	Clear

Wetted Casing Volume (2-inch diam) =	Full Sample Suite Obtained	Condition of Well, Remarks:
(H) x 0.~~163~~ 0.653 = 5cv Gallons 15	VOCs collected @ 0805	4" well. had Existing Poly Disp. Bailer in well used to sample/purge
H&S Comments:	Partial Sample Suite Obtained	
	No Sample Obtained	
H&S Signature	QC Samples: Dup, EB,, AB, MS/MSD (circle)	Sampler's Signature:
Protective Level Dermal: ~~D~~ C B A	Metals Sample(s) filtered	Checked by:
Respiratory: D C B A		Date:

APPENDIX D

PHOTOGRAPHS

Well 11MW02 in foreground, well 11MW01 next to drums; East Toll Gate Creek is aligned with trees; and Foxdale Condominiums are south of creek - Looking south



Water-bearing sand in well 11MW01, 19 to 24 feet bgs

Portion of screened interval in Well 11MW04, upgradient of North Plume

Well 11MW05 is downslope from curbed area - Looking northwest

Well 11MW05 – looking east-northeast; LDC Building in background

On-base direct-push groundwater sampling downgradient from well 11MW05

Preparing to drill well 11MW12, between wells 11MW01 and 11MW02

Denver “Blue”, below water-bearing zone in well 11MW06 (38 feet)

February 2010 off-base investigation south of East Toll Gate Creek - well LFW-8 in foreground and Building 1030 in background – Facing northeast

11CK01 sampling location in East Toll Gate Creek - Looking upstream

11CK02 sampling location in East Toll Gate Creek

11CK03 sampling location in East Toll Gate Creek

Storm drainage ditch crossing to access investigation area north of East Toll Gate Creek – Facing east

Well 11MW14 in foreground, 11CK01 in creek in line with tree, and well LFW-8 across creek – Facing west

Sandy, silty clay interval near top of water-bearing zone in well 11MW16

Well 11MW15 in pavement in foreground, well 1011MW07 near drums in graveled area, Building 1030 in background - Facing northeast

APPENDIX E

SURVEY AND GROUNDWATER-LEVEL DATA

Table E.1 (page 1 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
1011MW01	5552.81	5550.32	5/24/2006	45.25	5507.56
			6/19/2006	45.70	5507.11
			3/5/2009	43.27	5509.54
			4/8/2009	43.60	5509.21
			7/10/2009	42.23	5510.58
			6/23/2010	41.24	5511.57
1011MW02	5540.83	5538.14	5/19/2006	29.95	5510.88
			6/19/2006	29.60	5511.23
			3/5/2009	25.84	5514.99
			4/8/2009	25.49	5515.34
			7/10/2009	23.14	5517.69
			6/23/2010	22.76	5518.07
1011MW03	5534.94	5532.17	5/18/2006	34.90	5500.04
			6/19/2006	33.39	5501.55
			3/5/2009	30.38	5504.56
			4/8/2009	30.34	5504.60
			7/10/2009	30.09	5504.85
			6/23/2010	29.13	5505.81
1011MW04	5536.52	5534.16	5/18/2006	33.30	5503.22
			6/19/2006	*42.78*	5493.74
			6/30/2006	33.72	5502.80
			3/5/2009	30.39	5506.13
			4/8/2009	30.25	5506.27
			7/10/2009	29.55	5506.97
			6/23/2010	27.56	5508.96
1011MW05	5533.81	5530.79	5/19/2006	28.20	5505.61
			6/19/2006	28.38	5505.43
			6/30/2006	28.53	5505.28
1011MW06	5528.95	5526.18	5/19/2006	25.29	5503.66
			6/19/2006	25.07	5503.88
1011MW07	5540.95	5538.04	5/24/2006	27.83	5513.12
			6/19/2006	28.05	5512.90
			6/30/2006	27.90	5513.05
			3/5/2009	27.43	5513.52
			4/8/2009	27.86	5513.09
			7/10/2009	27.73	5513.22
			6/23/2010	26.47	5514.48
			7/21/2010	26.06	5514.89
			8/2/2010	25.95	5515.00
			8/20/2010	25.82	5515.13
			8/27/2010	25.84	5515.11
			9/3/2010	26.08	5514.87
1011MW08	5541.40	5538.39	5/19/2006	23.93	5517.47
			6/19/2006	29.30	5512.10
			6/30/2006	29.16	5512.24
			3/5/2009	25.04	5516.36
			4/8/2009	25.24	5516.16
			7/10/2009	23.46	5517.94
			6/23/2010	22.60	5518.80

Table E.1 (page 2 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
11MW01	5516.67	5513.37	4/8/2009	12.59	5504.08
			7/10/2009	11.25	5505.42
			6/23/2010	11.64	5505.03
11MW02	5515.18	5515.68	4/8/2009	10.69	5504.49
			7/10/2009	9.36	5505.82
			6/23/2010	9.69	5505.49
11MW03	5525.97	5526.78	4/8/2009	22.26	5503.71
			7/10/2009	21.00	5504.97
			6/23/2010	19.81	5506.16
11MW04	5541.76	5538.90	4/8/2009	*31.05*	*5510.71*
			7/10/2009	22.42	5519.34
			6/23/2010	20.85	5520.91
11MW05	5537.51	5534.61	4/8/2009	29.28	5508.23
			7/10/2009	27.41	5510.10
			6/23/2010	27.02	5510.49
11MW06	5530.55	5527.67	4/8/2009	24.39	5506.16
			7/10/2009	22.54	5508.01
			6/23/2010	22.68	5507.87
11MW07	5525.49	5522.27	4/8/2009	18.64	5506.85
			7/10/2009	16.72	5508.77
			6/23/2010	16.66	5508.83
11MW08	5520.15	5517.01	4/8/2009	14.59	5505.56
			7/10/2009	12.85	5507.30
			6/23/2010	13.17	5506.98
11MW09	5541.36	5538.80	7/10/2009	29.83	5511.53
			6/23/2010	29.49	5511.87
11MW10	5536.43	5536.92	7/10/2009	26.34	5510.09
			6/23/2010	25.91	5510.52
11MW11	5541.23	5538.40	7/10/2009	29.44	5511.79
			6/23/2010	29.15	5512.08
11MW12	5513.95	5514.54	7/10/2009	8.26	5505.69
			6/23/2010	8.64	5505.31
11MW13	5524.09	5521.10	7/10/2009	17.12	5506.97
			6/23/2010	17.44	5506.65
11MW14	5512.03	5510.05	*6/23/2010*	*17.72*	*5494.31*
			7/21/2010	*17.78*	*5494.25*
			8/2/2010	*16.18*	*5495.85*
			8/20/2010	*14.16*	*5497.87*
			8/27/2010	*13.68*	*5498.35*
			9/3/2010	*13.37*	*5498.66*
			9/10/2010	*13.17*	*5498.86*
11MW15	5536.56	5536.99	*6/23/2010*	*36.04*	*5500.52*
			7/21/2010	24.45	5512.11
			8/2/2010	24.30	5512.26
			8/20/2010	24.29	5512.27
			8/27/2010	24.37	5512.19
			9/3/2010	24.55	5512.01
11MW16	5528.56	5525.84	6/23/2010	20.52	5508.04
2WPMW01	5524.12	5521.26	Feb-05	19.28	5504.84
			Jun-06	20.60	5503.52
			3/5/2009	17.08	5507.04
			4/8/2009	16.80	5507.32
			7/10/2009	15.05	5509.07
			6/23/2010	14.96	5509.16

Table E.1 (page 3 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
710MW01[c]	5540.07	5537.25	5/18/2006	33.39	5506.68
			6/19/2006	33.8	5506.27
			4/8/2009	30.62	5509.45
			7/10/2009	29.14	5510.93
			6/23/2010	28.94	5511.13
710MW02[c]	5537.24	5534.38	5/18/2006	30.67	5506.57
			6/19/2006	31.02	5506.22
			3/5/2009	28.20	5509.04
			4/8/2009	28.36	5508.88
			7/10/2009	26.79	5510.45
			6/23/2010	26.05	5511.19
710MW03[c]	5536.78	5534.07	5/18/2006	30.28	5506.50
			6/19/2006	30.74	5506.04
			6/30/2006	30.78	5506.00
			3/5/2009	27.95	5508.83
			4/8/2009	28.09	5508.69
			7/10/2009	26.40	5510.38
			6/23/2010	25.77	5511.01
710MW04[c]	5536.62	5533.87	5/18/2006	30.12	5506.50
			6/19/2006	30.58	5506.04
			6/30/2006	30.62	5506.00
			3/5/2009	27.80	5508.82
			4/8/2009	27.95	5508.67
			7/10/2009	26.27	5510.35
			6/23/2010	25.57	5511.05
LDC-B1[c]	5541.25	5539.80	6/19/2006	20.61	5520.64
LDC-B2[c]	5540.78	5540.23	6/19/2006	20.88	5519.90
LDC-B3[c]	5538.56	5538.88	6/19/2006	19.95	5518.61
LDC-B4[c]	5541.87	5541.14	6/19/2006	20.04	5521.83
LDC-B5[c]	5544.28	5543.14	6/19/2006	21.25	5523.03
LDC-B6[c]	5539.87	5539.25	6/19/2006	18.23	5521.64
LFW-6	5547.49	5544.92	Jan-89	32.70	5514.79
			Aug-91	35.25	5512.24
			Apr-98	36.99	5510.50
			Jun-98	ND	ND
			Dec-98	36.73	5510.76
			Jun-99	33.78	5513.71
			Dec-99	32.79	5514.70
			Oct-01	33.38	5514.11
			Mar-02	34.52	5512.97
			Feb-05	35.00	5512.49
			Jun-06	35.40	5512.09
			4/8/2009	31.63	5515.86
			7/10/2009	27.97	5519.52
			6/23/2010	27.73	5519.76

Table E.1 (page 4 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
LFW-7	5526.01	5524.59	Jan-89	16.80	5509.21
			Aug-91	22.60	5503.41
			Apr-98	20.12	5505.89
			Jun-98	ND	ND
			Dec-98	19.42	5506.59
			Jun-99	16.44	5509.57
			Dec-99	16.03	5509.98
			Oct-01	16.90	5509.11
			Mar-02	18.11	5507.90
			Feb-05	17.18	5508.83
			Jun-06	18.98	5507.03
			4/8/2009	14.21	5511.80
			7/10/2009	10.55	5515.46
			6/23/2010	10.94	5515.07
LFW-8	5510.05	5508.61	Jan-89	12.90	5497.15
			Aug-91	12.83	5497.22
			Apr-98	15.00	5495.05
			Jun-98	ND	ND
			Dec-98	15.30	5494.75
			Jun-99	12.90	5497.15
			Dec-99	14.34	5495.71
			Oct-01	15.60	5494.45
			Mar-02	16.32	5493.73
			Feb-05	16.29	5493.76
			Jun-06	17.52	5492.53
			4/8/2009	14.41	5495.64
			7/10/2009	11.11	5498.94
			6/23/2010	11.55	5498.50
			7/21/2010	11.88	5498.17
			8/2/2010	12.00	5498.05
			8/20/2010	12.23	5497.82
			8/27/2010	12.57	5497.48
			9/3/2010	12.96	5497.09
			9/10/2010	13.34	5496.71
LFW-13	5522.22	5520.63	Jan-89	ND	ND
			Aug-91	14.30	5507.92
			Apr-98	16.55	5505.67
			Jun-98	16.55	5505.67
			Dec-98	16.17	5506.05
			Jun-99	12.44	5509.78
			Dec-99	12.35	5509.87
			Oct-01	13.49	5508.73
			Mar-02	14.22	5508.00
			Feb-05	14.20	5508.02
			Jun-06	15.20	5507.02
			4/8/2009	10.09	5512.13
			7/10/2009	6.71	5515.51
			6/23/2010	7.61	5514.61

Table E.1 (page 5 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
LFW-14	5528.67	5526.65	Jan-89	ND	ND
			Aug-91	16.17	5512.50
			Apr-98	18.95	5509.72
			Jun-98	ND	ND
			Dec-98	18.84	5509.83
			Jun-99	16.02	5512.65
			Dec-99	14.83	5513.84
			Oct-01	15.55	5513.12
			Mar-02	16.32	5512.35
			Feb-05	16.82	5511.85
			Jun-06	17.35	5511.32
			4/8/2009	12.72	5515.95
			7/10/2009	9.25	5519.42
			6/23/2010	9.98	5518.69
LFW-19	5521.48	5519.49	Apr-98	ND	ND
			Jun-98	17.94	5503.54
			Dec-98	17.75	5503.73
			Jun-99	15.37	5506.11
			Dec-99	15.20	5506.28
			Oct-01	17.02	5504.46
			Mar-02	17.00	5504.48
			Feb-05	17.11	5504.37
			6/6/2006	NA[d]	NA[d]
			7/6/2006	17.0	5504.48
			3/5/2009	15.05	5506.43
			4/8/2009	14.69	5506.79
			7/10/2009	13.01	5508.47
			6/23/2010	13.22	5508.26
LFW-20	5518.52	5515.75	Jun-06	14.95	5503.57
			3/5/09	10.58	5507.94
			4/8/2009	9.83	5508.69
			7/10/2009	7.58	5510.94
			6/23/2010	8.13	5510.39
MW-3	5524.22	5521.54	Jan-89	16.90	5507.32
			Aug-91	Dry	Dry
			Apr-98	20.08	5504.14
			Jun-98	ND	ND
			Dec-98	19.76	5504.46
			Jun-99	17.32	5506.90
			Dec-99	17.14	5507.08
			Oct-01	19.21	5505.01
			Mar-02	19.15	5505.07
			Feb-05	19.35	5504.87
			Jun-06	20.75	5503.47
			3/5/2009	17.17	5507.05
			4/8/2009	16.94	5507.28
			7/10/2009	15.15	5509.07
			6/23/2010	14.99	5509.23

Table E.1 (page 6 of 6)
Historical and Current Groundwater Elevations
Site 11 and Adjacent Site Wells
Buckley Air Force Base, Colorado

Well ID	TOC Elevation[a] (ft amsl)	Ground Elevation[a] (ft amsl)	Date Sampled/ Measured	Depth to Water[b] (ft below TOC)	Water Elevation (ft amsl)
MW-4	5521.34	5518.98	Jan-89	14.80	5506.54
			Aug-91	Dry	Dry
			Apr-98	17.88	5503.46
			Jun-98	ND	ND
			Dec-98	17.60	5503.74
			Jun-99	15.25	5506.09
			Dec-99	15.08	5506.26
			Oct-01	16.90	5504.44
			Mar-02	16.89	5504.45
			Feb-05	16.98	5504.36
			Jun-06	NA[d]	NA[d]
			4/8/2009	14.62	5506.72
			7/10/2009	12.90	5508.44
			6/23/2010	13.09	5508.25
MW710-1[c]	5538.09	5536.45	6/19/2006	32.01	5506.08
			4/8/2009	29.24	5508.85
			7/10/2009	27.76	5510.33
			6/23/2010	27.06	5511.03
SG21W[c]	5533.81	5533.57	6/19/2006	27.75	5506.06

[a]The elevations for wells are from Versar's surveys, beginning with a February 2005 survey, because January 2005 elevation checks indicated discrepancies with previously reported elevations.
[b]Depths to water from 1989-2002 are from URS (2002), except as corrected for LFW-19 for Dec-98.
[c]Additional water levels are contained in the LNAPL report.
[d]Access to the well was restricted, and a water level could not be obtained.

Water levels that had not apparently stabilized are shown in italics.

ft	feet
ft bgs	feet below ground surface
ft amsl	feet above mean sea level
LNAPL	light non-aqueous phase liquid
NA	no access
ND	no data
TOC	top of polyvinyl chloride (PVC) casing
URS	URS Group, Inc.

Table E.2
Coordinates and Elevations for RI Wells, Direct-Push Locations, and Creek Sample Locations

Loc ID	State Plane North[a]	State Plane East[a]	MP Elevation	Ground Elevation
11CK01	1682672.5635	3204328.4863		5498.30
11CK02	1682575.2002	3204542.4577		5499.85
11CK03	1682534.2034	3204654.3151		5501.35
11DP01	1682582.1688	3205108.9983		5519.17
11DP02	1682558.4388	3205154.5848		5519.69
11DP03	1682606.0427	3205064.4450		5517.89
11DP04	1682625.5894	3205135.0961		5524.85
11DP05	1682599.3461	3205181.2775		5523.70
11DP06	1682650.3996	3205091.2316		5524.38
11DP07	1682654.2451	3205152.3649		5525.48
11DP08	1682634.5349	3205169.7537		5525.40
11DP09	1682673.0509	3205135.6740		5525.77
11DP10	1682691.8628	3205119.5639		5526.45
11DP11	1682710.6226	3205103.4703		5526.71
11DP12	1682616.1750	3205186.7935		5524.81
11DP13	1682657.9460	3205126.0246		5525.37
11DP14	1682686.0374	3205080.6835		5525.37
11DP15	1682701.0653	3205111.4241		5526.61
11DP16	1682637.6286	3205112.9062		5524.72
11DP17	1682660.7563	3205071.2036		5522.24
11DP18	1682674.1001	3205048.1439		5522.51
11DP19	1682686.6462	3205025.2457		5523.10
11DP20	1682699.0568	3205002.6259		5522.94
11DP21	1682641.3361	3204998.9099		5519.45
11DP22	1682664.7617	3204955.3378		5520.51
11DP23	1682711.6998	3204978.4440		5523.77
11DP24	1682699.6976	3204943.2276		5523.37
11DP25	1682735.7972	3204935.4013		5525.03
11DP26	1682688.5567	3204911.5498		5522.23
11DP27	1682640.8737	3204759.4614		5514.95
11DP28	1682616.2275	3204761.5608		5514.23
11DP29	1682716.4940	3204756.5282		5516.67
11DP30	1682590.6335	3204764.0191		5513.58
11DP31	1682623.1241	3204878.0339		5515.92
11DP32	1682620.3768	3204933.9991		5516.37
11DP33	1682555.9434	3204520.0159		5509.98
11DP34	1682583.4579	3204486.8170		5509.85
11DP35	1682538.8921	3204551.4413		5510.57
11DP36	1682518.8676	3204576.6924		5510.82
11DP37	1682555.9934	3204485.9692		5509.94
11DP38	1682530.2025	3204481.2585		5510.60
11DP39	1682554.1039	3204428.9808		5509.76
11DP40	1682579.5950	3204438.3222		5509.27
11DP41	1682602.1288	3204448.9113		5509.57
11DP42	1682581.1006	3204461.6638		5509.30
11DP43	1682507.8906	3204609.9853		5511.34
11DP44	1682497.6614	3204641.9965		5512.22
11DP45	1682516.9961	3204550.8294		5511.23
11DP46	1682617.6186	3204410.3899		5509.42
11DP47	1682592.8633	3204406.5729		5508.93
11DP48	1682566.1407	3204403.6017		5509.36
11DP49	1682628.7855	3204368.1994		5509.36
11DP50	1682602.8826	3204365.6901		5508.77
11DP51	1682643.9014	3204326.8227		5509.08
11DP52	1682656.8538	3204283.7725		5508.92

Table E.2
Coordinates and Elevations for RI Wells, Direct-Push Locations, and Creek Sample Locations

Loc ID	State Plane North[a]	State Plane East[a]	MP Elevation	Ground Elevation
11DP53	1682667.8208	3204242.7517		5508.60
11DP54	1682570.0000	3204503.0000		NM
11DP55	1682492.8867	3204674.4396		5512.87
11DP56	1682576.2359	3204644.6898		5511.34
11DP57	1682599.8374	3204642.8763		5510.64
11DP58	1682587.6108	3204610.1692		5510.63
11DP59	1682619.8160	3204640.5469		5510.71
11DP60	1682558.4748	3204671.9203		5511.12
11DP61	1682602.4847	3204583.2946		5511.12
11DP62	1682628.4516	3204584.3123		5510.99
11DP63	1682613.1738	3204608.5796		5510.43
11DP64	1682621.5535	3204545.2610		5510.55
11DP65	1682645.5369	3204496.2464		5510.68
11DP66	1682662.7302	3204584.9161		5512.40
11DP67	1682677.5542	3204493.9270		5510.67
11DP68	1682660.8228	3204446.0261		5510.13
11DP69	1682674.9489	3204394.3403		5510.05
11DP70	1682553.3941	3204715.2145		5512.34
11DP71	1682608.4411	3204692.2008		5511.55
11DP72	1682665.3295	3204547.4264		5511.65
11DP73	1682705.1186	3204492.2035		5510.90
11DP74	1682692.6640	3204445.4403		5509.58
11DP75	1682695.8712	3204396.1038		5509.23
11DP76	1682690.4766	3204344.8238		5509.74
11DP77	1682708.7716	3204295.8092		5508.83
11DP78	1682717.3993	3204348.1469		5508.98
11DP79	1682696.3290	3204544.4692		5512.35
11DP80	1682652.1491	3204622.8078		5511.60
11DP81	1682718.9709	3204444.9404		5509.75
11DP82	1682727.0626	3204541.5800		5511.97
11MW01	1682549.0256	3204772.8310	5516.67	5513.37
11MW02	1682666.4418	3204754.2110	5515.18	5515.68
11MW03	1683027.0881	3204752.1633	5525.97	5526.78
11MW04	1683139.1717	3204986.6026	5541.76	5538.9
11MW05	1682769.4672	3205333.8438	5537.51	5534.61
11MW06	1682730.9444	3205071.4729	5530.55	5527.67
11MW07	1682554.6190	3205228.4074	5525.49	5522.27
11MW08	1682611.1636	3204993.3299	5520.15	5517.01
11MW09	1682831.7230	3205392.3863	5541.36	5538.80
11MW10	1682821.5048	3205304.0539	5536.43	5536.92
11MW11	1682776.9445	3205386.3754	5541.23	5538.40
11MW12	1682616.6149	3204755.4710	5513.95	5514.54
11MW13	1682673.5133	3204942.7038	5524.09	5521.10
11MW14	1682674.6050	3204396.7436	5512.03	5510.05[b]
11MW15	1683078.4165	3204884.3722	5536.56	5536.99
11MW16	1682675.0509	3205135.9914	5528.56	5525.84

[a]Colorado Central Zone, NAD 83
[b]Ground elevation from adjacent 11DP69
MP - measuring point
NM - not measured

APPENDIX F

IDW DISPOSAL DOCUMENTATION

Please print or type
(Form designed for use on elite (12-pitch) typewriter.)

NON-HAZARDOUS WASTE MANIFEST

WASTE MANAGEMENT 200,371

220904

GENERATOR

1. Generator's Name and Project Location
Buckley AFB
450 CES/CEV, 650 South Aspen St, MS-86
Buckley AFB, 80011
1a. Generator's Phone (720) 847-9059

2. Bill to: ET Technologies
2a. Account # CSI 389

3. Transporter 1 Company Name: ET Technologies, Inc. 10000 S Dennsfield Rd, Ste 100
3a. Transporter's Phone: 303-680-9414

4. Transporter 2 Company Name
4a. Transporter's Phone

5. Designated Management Facility Name and Site Address
Conservation Services
41800 E. 88th Ave.
Bennett, CO 80102
5a. Facility's Phone (303)644-4335

6. Waste Code/Profile #	Waste Description	Quantity	Units
105251 CO	IDW WATER 8x55 Dm	440	GAL

IF ASBESTOS WASTE (Please check the appropriate box)

Waste Code/Profile #		Waste Description	Quantity	Units
		Friable RQ Asbestos Class 9 NA ~~2212 PG III~~		
		Nonfriable Asbestos		

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not a hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

Printed/Typed Name: Robert Krumberger — Signature — Month 5 Day 4 Year 09

TRANSPORTER

9. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Name: Joel Carter — Signature — Month 5 Day 4 Year 09

10. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Name — Signature — Month Day Year

FACILITY

11. Discrepancy Indication Space

12. Ticket # 69824

13. Management Method/Location ☒ Solidification ☐ Monofill ☐ Landfill ☐ Bio-Beds
Grid Location (if applicable): 18 Phase / N39° 51.091 W104° 30.050

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.

Printed/Typed Name: Joyce Newman — Signature — Month 05 Day 04 Year 09

ORIGINAL – RETURN TO GENERATOR

Please print or type
(Form designed for use on elite (12-pitch typewriter)

NON-HAZARDOUS WASTE MANIFEST

WM WASTE MANAGEMENT 225,480

1046074

GENERATOR

1. Generator's Name and Complete Project Address: Buckley AFB, 450 CES/CEV, 650 South Aspen St. MS-86, Buckley AFB, 80011

1a. Generator's Phone: (720) 847-9059

2. Bill to: ET Tech

2a. Account #: D 3214

3. Transporter: Complete Company Name and Address: ET Technologies, Inc. 10000 S. Dransfeldt Rd, Ste 100, Parker, Co

3a. Transporter's Phone: 303-680-9414

4. Transporter: Complete Company Name and Address:

4a. Transporter's Phone:

5. Designated Management Facility Name and Site Address: Denver Arapahoe Disposal Site, 3500 South Gun Club Road, Aurora, CO 80018

5a. Facility's Phone: (720) 876-2620

6. Waste Code/Profile #	Waste Description	Quantity	Units
105233CO	IDW Soil	5 yds	YDS

NON-FRIABLE ASBESTOS WASTE ONLY (Friable may not be shipped on this manifest)

Waste Code/Profile #	Waste Description	Quantity	Yards or Drums
	Nonfriable Asbestos		

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

TRANSPORTER

8a. Contractor/Generator
Printed/Typed Full Name: Robert Kurnmberger
Signature (Full Name): Robert Kurnmberger
Month Day Year: 05 04 09

9. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Full Name: Dan L Smith
Signature (Full Name): Dan L Smith
Month Day Year: 05 06 09

10. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Full Name:
Signature (Full Name):
Month Day Year:

FACILITY

11. Discrepancy indication Space

Initials of Person noting discrepancy _____ Date _____

12. Ticket #: 1148088

13. Management Method/Location ☐ Solidification ☐ Monofill ☒ Landfill ☐ Bio-Beds

Grid Location (if applicable): _____

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.

Printed/Typed Full Name: Kim Barber
Signature (Full Name): Kim Barber
Month Day Year: 5 6 09

ORIGINAL - RETURN TO GENERATOR

Please print or type
(Form designed for use on elite (12-pitch) typewriter.)

NON-HAZARDOUS WASTE MANIFEST

WASTE MANAGEMENT

222,372

281088

GENERATOR

1. Generator's Name and Project Location
Buckley AFB
450 CES/CEV 650 S. Aspen St., MS-86
Buckley AFB, CO

1a. Generator's Phone

2. Bill to: ET Technologies CSI 389

2a. Account #

3. Transporter 1 Company Name
E.T. Technologies, Inc. 10000 S. Dransfeldt Parker, CO 80134

3a. Transporter's Phone 303-680-9414

4. Transporter 2 Company Name

4a. Transporter's Phone

5. Designated Management Facility Name and Site Address
Conservation Services
41800 E. 88th Ave.
Bennett, CO 80102

5a. Facility's Phone (303)644-4335

6. Waste Code/Profile #	Waste Description	Quantity	Units
105251 CO	IDW Water 11x55 DM	605	GAL

IF ASBESTOS WASTE (Please check the appropriate box)

Waste Code/Profile #		Waste Description	Quantity	Units
	Friable	RQ Asbestos Class 9 NA 2212 PG III		
	Nonfriable Asbestos			

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not a hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

TRANSPORTER

Printed/Typed Name	Signature	Month	Day	Year
DALE CARLSON	Dale Carlson	11	10	09

9. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Month	Day	Year
JOSE H HERNANDEZ	[signature]	11	10	09

10. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Month	Day	Year

FACILITY

11. Discrepancy Indication Space

12. Ticket # 73375

13. Management Method/Location ☒ Solidification ☐ Monofill ☐ Landfill ☐ Bio-Beds

Grid Location (if applicable): 18 Phase I N39° 51.064 W104° 30.057

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.

Printed/Typed Name	Signature	Month	Day	Year
Joyce Newman	Joyce Newman	11	11	09

ORIGINAL -- RETURN TO GENERATOR

Please print or type
(Form designed for use on elite (12-pitch typewriter))

NON-HAZARDOUS WASTE MANIFEST

WASTE MANAGEMENT

1046070

GENERATOR

1. Generator's Name and Complete Project Address
Buckley AFB
460 CES/CEV 6505. Aspen St., MS-86
Buckley AFB, CO

1a. Generator's Phone 720-842-9059

2. Bill to: ET Tech
2a. Account # D 3214

3. Transporter: Complete Company Name and Address
E.T. Technologies, Inc. 10000 S. Dransfeldt Parker, CO

3a. Transporter's Phone 303-680-9414

4. Transporter: Complete Company Name and Address

4a. Transporter's Phone

5. Designated Management Facility Name and Site Address
Denver Arapahoe Disposal Site
3500 South Gun Club Road
Aurora, CO 80018

5a. Facility's Phone (720)876-2620

6. Waste Code/Profile #	Waste Description	Quantity	Units
105233CO	IDW Soil 12x55 DM	2.5	CY

NON-FRIABLE ASBESTOS WASTE ONLY (Friable may not be shipped on this manifest)

Waste Code/Profile #	Waste Description	Quantity	Yards or Drums
	Nonfriable Asbestos		

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

TRANSPORTER

8a. Contractor/Generator
Printed/Typed Full Name: DALE CARLSON
Signature (Full Name): Dale Carlson
Month 11 Day 10 Year 09

9. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Full Name: JOSE H HERNANDEZ
Signature (Full Name): Jose H Hernandez
Month 11 Day 10 Year 09

10. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Full Name:
Signature (Full Name):
Month Day Year

FACILITY

11. Discrepancy indication Space
Initials of Person noting discrepancy _____ Date _____

12. Ticket # 1273010

13. Management Method/Location ☐ Solidification ☐ Monofill ☒ Landfill ☐ Bio-Beds
Grid Location (if applicable): _____

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.
Printed/Typed Full Name: Kim Paulse
Signature (Full Name): Kim Paulse
Month 11 Day 10 Year 09

ORIGINAL - RETURN TO GENERATOR

Please print or type
(Form designed for use on elite (12-pitch) typewriter.)

NON-HAZARDOUS WASTE MANIFEST

WASTE MANAGEMENT 200,371

220905

GENERATOR

1. Generator's Name and Project Location: Buckley AFB, 660 S. Aspen St. M58L, Buckley AFB, CO

1a. Generator's Phone: (720) 847-9059

2. Bill to: ET Technologies CSI 389

2a. Account #

3. Transporter 1 Company Name: E.T. Technologies, Inc.

3a. Transporter's Phone: 303-680-9414

4. Transporter 2 Company Name

4a. Transporter's Phone

5. Designated Management Facility Name and Site Address: Conservation Services, 41800 E. 88th Ave., Bennett, CO 80102

5a. Facility's Phone: (303)644-4335

6. Waste Code/Profile #	Waste Description	Quantity	Units
10525, CO	IDW Water	260	Gal
	Control # 7162		

IF ASBESTOS WASTE (Please check the appropriate box)

Waste Code/Profile #		Waste Description	Quantity	Units
		Friable RQ Asbestos Class 9 NA 2212 PG III		
		Nonfriable Asbestos		

10 AUG -6 PM 3:21

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not a hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

Printed/Typed Name	Signature	Month	Day	Year
DALE CARLSON	Dale Carlson	08	05	10

TRANSPORTER

9. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Month	Day	Year
Fred Aquilar	Fred Aquilar	08	05	10

10. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Month	Day	Year
Dan Smith	Dan Smith	08	06	10

FACILITY

11. Discrepancy Indication Space

12. Ticket # 78525

13. Management Method/Location ☒ Solidification ☐ Monofill ☐ Landfill ☐ Bio-Beds

Grid Location (if applicable): Elev 5286' N39° 51.120 W104° 30.142

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.

Printed/Typed Name	Signature	Month	Day	Year
Joyce Newman	Joyce Newman	08	06	10

ORIGINAL – RETURN TO GENERATOR

NON-HAZARDOUS WASTE MANIFEST	WASTE MANAGEMENT 226,993	1120363

GENERATOR

1. Generator's Name and Complete Project Address: Buckley AFB, 6605 Aspen St., MS 86, Buckley AFB, CO

1a. Generator's Phone: (720) 847-9059

2. Bill to: ET ~~Environmental~~

2a. Account #: D 13851

3. Transporter: Complete Company Name and Address: ET Technologies, Inc, 10000 S. Drusfield Rd. Parker, CO 80134

3a. Transporter's Phone: 303-680-9414

4. Transporter: Complete Company Name and Address:

4a. Transporter's Phone:

5. Designated Management Facility Name and Site Address: Denver Arapahoe Disposal Site, 3500 South Gun Club Road, Aurora, CO 80018

5a. Facility's Phone: (720) 876-2620

6. Waste Code/Profile #	Waste Description	Quantity	Units
105233 CO	1 DW Soil	1	yd3

NON-FRIABLE ASBESTOS WASTE ONLY (Friable may not be shipped on this manifest)

Waste Code/Profile #	Waste Description	Quantity	Yards or Drums
	Nonfriable Asbestos		

7. Regulatory Agency:
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Emergency Notification: CHEMTREC (800) 424-9300
24 hr. toll free phone number

8. Contractor/Generator Certification:
I hereby certify that the above described waste is not hazardous waste as defined by federal, state or local regulations and does not contain regulated quantities of PCB's or radioactive materials. This waste has been accurately classified, described, packaged, marked and labeled and is in proper condition for transportation according to applicable international and governmental regulations.

TRANSPORTER

8a. Contractor/Generator

Printed/Typed Full Name	Signature (Full Name)	Month	Day	Year
DALE CARLSON	Dale Carlson	08	05	10

9. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Full Name	Signature (Full Name)	Month	Day	Year
Federico	[illegible]	08	05	10

10. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Full Name	Signature (Full Name)	Month	Day	Year
DAN LSmith	Dan LSmith	08	06	10

FACILITY

11. Discrepancy indication Space

Initials of Person noting discrepancy _____ Date _____

12. Ticket # 1415249

13. Management Method/Location ☐ Solidification ☐ Monofill ☒ Landfill ☐ Bio-Beds

Grid Location (if applicable): _____

14. Facility Owner or Operator: Certification of receipt of waste materials covered by this manifest except as noted in item 11.

Printed/Typed Full Name	Signature (Full Name)	Month	Day	Year
DADS Jaime Adamson	[illegible]	8	6	10

ORIGINAL - RETURN TO GENERATOR

APPENDIX G

DATA QUALITY ASSESSMENT AND LABORATORY DATA

ANALYTICAL DATA EVALUATION SUMMARY

Samples were collected and analyzed in accordance with the *Final Quality Program Plan* (QPP) *Site 11 (Building 1011 Area) Remedial Investigation, Buckley Air Force Base, Colorado* (March 2009); the *Final Addendum* (July 2009) and the *Final Second Addendum* (August 2009) *to the March 2009 Final Quality Program Plan (QPP) for Site 11* (subsequently referred to in this section as the QPP and QPP Addenda); the *Basewide Quality Assurance Project Plan* (QAPP), *Buckley Air Force Base* (March 2004); and the AFCEE QAPP Version 3.1 (August 2001).

Sampling and Analysis Summary

Groundwater Grab Sampling and Analysis

Eighty-two (82) field groundwater grab samples were collected and analyzed using direct-push drilling techniques and tooling and field analytical techniques as described in the QPP Addenda. As analytical results were obtained, the data were used to guide the locations of subsequent grab samples and suggest locations for installation of permanent monitoring wells. The samples were analyzed in an on-site mobile field laboratory operated by ChemSolutions of Larkspur, CO. The laboratory used the purge and trap technique to introduce the samples to a gas chromatograph/ mass spectrometer (GC/MS). The specific volatile organic compounds (VOCs) of interest included tetrachloroethene (PCE) and its daughter products trichloroethene (TCE), cis-1,2-dichloroethene, trans-1,2 dichloroethene (DCE), and vinyl chloride; and chloroform. In addition to the groundwater grab sample analysis, aliquots of three surface water and three sediment samples were also analyzed on-site in the ChemSolutions mobile laboratory using analytical techniques similar to those used for the groundwater grab analysis.

The data were generated by a rigorous analytical method (EPA SW-846 Method 8260B), and provided identification and quantitation (analyte-specific). The results are categorized as *screening data* because most but not all of the quality control (QC) procedures and documentation specified by the Basewide QAPP (March 2004) and the AFCEE QAPP (AFCEE, 2001) were required by the QPP and QPP Addenda, and only intermediate project decisions were based on the data. The ChemSolutions laboratory reports are reproduced in this appendix.

Surface Water and Sediment Sampling and Analysis

Surface water and sediment samples were collected at three locations as described in the QPP Addenda. The surface water samples were collected by slowly immersing unpreserved 40-milliliter (mL) volatile organic analysis vials (VOA) directly into the surface water, then slowly removing the vials. The sediment samples were collected from shallow water using a 4-ounce jar to fill and containerize the samples. Aliquots of the samples were analyzed on-site in the ChemSolutions mobile laboratory as described above; these data were categorized as *screening data*. Additional sample aliquots were sent off-site for analysis to Microbac Laboratories of Marietta, Ohio (Microbac). Microbac used the purge and trap technique to introduce the samples to a GC/MS. Sixty-four (64) VOCs were analyzed, including the six target VOCs listed above for the grab groundwater sampling and two additional target analytes (carbon tetrachloride and

1,2-dichloroethane) for the northern portion of Site 11, as described in the QPP and QPP Addenda and listed in Table G-1.

The off-site laboratory data were generated by a rigorous analytical method (EPA SW-846 Method 8260B), and provided identification and quantitation (analyte-specific). The results are categorized as *definitive data* because all of the QC procedures and documentation specified by the Basewide QAPP (March 2004) and the AFCEE QAPP (AFCEE, 2001) were required by the QPP and QPP Addenda, and final project decisions were based on the data. The Microbac laboratory reports are reproduced in this appendix.

Groundwater Monitoring Well Sampling and Analysis

Forty-one (41) groundwater samples were collected from permanent monitoring wells using a polyvinyl chloride (PVC) bailer. The VOC samples were contained unpreserved in 40-mL VOA vials, and the samples for analysis of 1,4-dioxane were contained unpreserved in 1-liter glass bottles. The samples were sent off-site for analysis of VOCs and 1,4-dioxane to Microbac, and analyzed using GC/MS instrumentation as described in the QPP and QPP Addenda. Sixty-four (64) VOCs were analyzed, as listed in Table G-1.

The off-site laboratory data were generated by rigorous analytical methods (EPA SW-846 methods 8260B and 8270C), and provided identification and quantitation (analyte-specific). The results are categorized as *definitive data* because all of the QC procedures and documentation specified by the Basewide QAPP (March 2004) and the AFCEE QAPP (AFCEE, 2001) were required by the QPP Addenda, and final project decisions were based on the data. The Microbac laboratory reports are reproduced in this appendix.

Sample Management

The sample handling and custody procedures referenced in the QPP and the QPP Addenda were followed as prescribed. Sample containers were labeled with unique location identifiers during field collection, and chain-of-custody record forms were used to document the collection of field samples and their transport to the laboratory. Versar confirmed the specific tests to be performed by the laboratory, for each sample received and listed on the custody form prior to analysis.

Sample Preservation

Groundwater monitoring well samples and the surface water and sediment samples were transported off-site on ice and received at Microbac at temperatures between 1°C and 6°C. No preservatives were added to any of the samples in accordance with the QPP and the QPP Addenda.

Analytical Holding Times

All samples were analyzed within the QPP and QPP Addenda specified holding times.

Field QC Samples

The number and type of field QC samples listed in the QPP and QPP Addenda were collected as prescribed. Field QC samples collected for groundwater VOC analyses by the off-site laboratory included three ambient blanks, four field duplicates, and three sets of matrix spike/matrix spike duplicates (MS/MSD). Field QC samples collected for groundwater 1,4-dioxane analyses included one set of MS/MSD. No field QC samples were collected and analyzed for surface water and sediment samples.

Ambient Blanks

Three ambient blanks were collected (one during each of the three phases of groundwater monitoring well sample collection) for the analysis of VOCs to assess the potential introduction of contaminants from ambient sources. Acetone was detected in one ambient blank at a concentration (11 micrograms per liter [µg/L]) equal to or greater than analyte reporting limit [RL] (10 µg/L); acetone was not detected in any of associated field samples.

Equipment Blanks

No equipment blanks were collected during the groundwater monitoring well sampling; all collection devices were disposable and not used for multiple samples.

Field Duplicates

Four field duplicate groundwater monitoring samples were collected for the analysis of VOCs to assess the overall precision of the sample collection and analysis process. Target VOCs for Site 11 were detected within the prescribed limit of equal to or less than 20 relative percent difference (RPD) in each of the field duplicates except for specific field duplicate results for well 11MW05, as shown below. The reasons for the anomalous results were investigated but could not be determined.

Analyte	**Monitoring Well 11MW05 Date Collected: 7/7/2009**	**Monitoring Well 11MW05(FD) Date Collected: 7/7/2009**	**RPD**
PCE	60.2 µg/L	157 µg/L	89%
TCE	1.03 µg/L	2.18 µg/L	72%
	Date Collected: 6/25/2010	**Date Collected: 6/25/2010**	
PCE	34.1 µg/L	43.2 µg/L	24%

MS/MSD

Three pairs of MS/MSD groundwater monitoring samples were collected for the analysis of VOCs to assess the bias of the analytical method due to the sample matrix. Target VOCs were recovered within the prescribed limits of accuracy and precision in each of the MS/MSD samples, except for vinyl chloride (accuracy limit between 50% and 134%) which was recovered in monitoring well sample 11MW09 at 146% and 145% (sample collected July 7, 2009), and

recovered in monitoring well sample 11MW01 at 140% and 156% (sample collected June 24, 2010).

One pair of MS/MSD groundwater monitoring samples was collected for the analysis of 1,4-dioxane to assess the bias of the analytical method due to the sample matrix. 1,4-dioxane was recovered in monitoring well sample 11MW12 with the prescribed accuracy limits (between 30% and 104%) at 55% and 36%, but the RPD between the MS and MSD was above the precision limit of 30% at 41% (sample collected August 5, 2009).

Data Review

Data review is the process by which data are examined and evaluated to ensure that the sample results are of known and documented quality and meet the measurement quality objectives of the project. The Site 11 RI data review process consisted of the following related assessments:

Data Verification – a sample-specific assessment performed to determine whether the samples were collected and analyzed for the list of analytes and test methods specified in the QPP and QPP Addenda, and whether sample detection limits and QC measurement acceptance criteria were met.

Data Validation – a method-specific assessment performed for each sample matrix and analytical method to substantiate that the analytical requirements specified in the QPP and QPP Addenda have been met.

Data Usability – a project-specific assessment performed to determine the overall adequacy of the analytical data, and apply data qualifiers to the field samples based on their association to the field and laboratory QC samples.

<u>Data Verification and Data Validation</u>

Sample-specific data verification was performed for all samples analyzed and reported, including groundwater grab, surface water, and sediment samples (screening-level data); and surface water, sediment, and groundwater monitoring well samples (definitive-level data). A method-specific data validation was performed on all definitive-level data analyzed for VOCs and 1,4-dioxane. A data review report summarizing the results of the definitive-level (groundwater monitoring well, surface water, and sediment) data verification and data validation was prepared for each of the laboratory data packages received, and is included in this appendix.

Analytical Data Quality Summary

The data quality indicators of precision, accuracy, representativeness, completeness, and sensitivity were used to determine the overall acceptability and usability of the analytical results for the Site 11 RI project decisions. In general, the analytical data met all acceptance criteria.

The data qualifiers listed in the individual data review reports are considered the final determination of data quality and usability for the sample results. It should be noted that a

qualifier flag ("F") was applied to samples when an analyte was identified and quantitated below the project RL, but above the laboratory method detection limit (MDL).

Precision

Analytical precision was evaluated by measuring the variability of ongoing laboratory control sample (LCS) results. All LCS had acceptable results for the analysis of target VOCs and 1,4-dioxane; therefore, analytical precision was judged to be acceptable.

Total precision was evaluated by measuring the variability associated with the entire sampling and analysis process, as determined by the collection and analysis of field duplicate groundwater monitoring well samples for VOCs (no field duplicate groundwater monitoring well samples were collected and analyzed for 1,4-dioxane).

In general, the data indicate the collection and analysis of project VOCs to have been relatively precise. The anomalous results observed for monitoring well 11MW05 may be attributed to hydrogeologic characteristics rather than the result of imprecise sample collection or analysis techniques.

Accuracy/Bias

Analytical accuracy was evaluated by measuring the percent recovery of target analytes added to the LCS and the percent recovery of surrogate analytes added to field samples and laboratory QC samples analyzed for VOCs and 1,4-dioxane. All LCS and surrogate results met project-required control limits for accuracy, demonstrating the project VOC and 1,4-dioxane sample results to be relatively accurate.

Analytical bias was evaluated by measuring the percent recovery and precision of target analytes added to the groundwater monitoring well MS/MSD samples. All target VOCs were within established recovery and precision control limits except for the recovery of vinyl chloride, which was recovered at percentages greater than the upper control limit in the MS/MSD samples; vinyl chloride was not detected in any groundwater monitoring well samples. 1,4-Dioxane was within the established recovery control limits, but the RPD was slightly greater than the precision limit; 1,4-dioxane was not detected in the two groundwater samples analyzed.

The MS/MSD recoveries indicate the project VOC and 1,4-dioxane sample results are relatively unbiased.

Representativeness

Representativeness was evaluated by considering the total sampling and analysis precision data in relation to the measurement objectives. The collected sample data were judged to adequately represent the site conditions during the Site 11 RI.

Completeness

Completeness was evaluated by measuring the amount of data rejected due to deficiencies in the ability to analyze the samples and meet QC criteria. The percent completeness, defined as the percentage of sample data by analyte and matrix not qualified as rejected, was 100 percent for each analytical method.

Sensitivity

Analytical sensitivity, the ability to detect specific target analytes at specified concentrations, was evaluated by comparing the groundwater monitoring well VOC and 1,4-dixoane results, and surface water and sediment VOC results, to the laboratory MDLs and RLs.

All laboratory MDLs were equal to or less than one-half the corresponding laboratory RLs as required by the Basewide QAPP. The VOC and 1,4-dioxane RLs were equivalent to the values specified in the QPP and the Addenda. Table G-1 indicates the detection and reporting limits associated with the analysis of the project groundwater monitoring well samples.

Table G-1
Site 11 RI Detection and Reporting Limits for
Surface Water and Groundwater Monitoring Well Samples
Buckley Air Force Base, Colorado

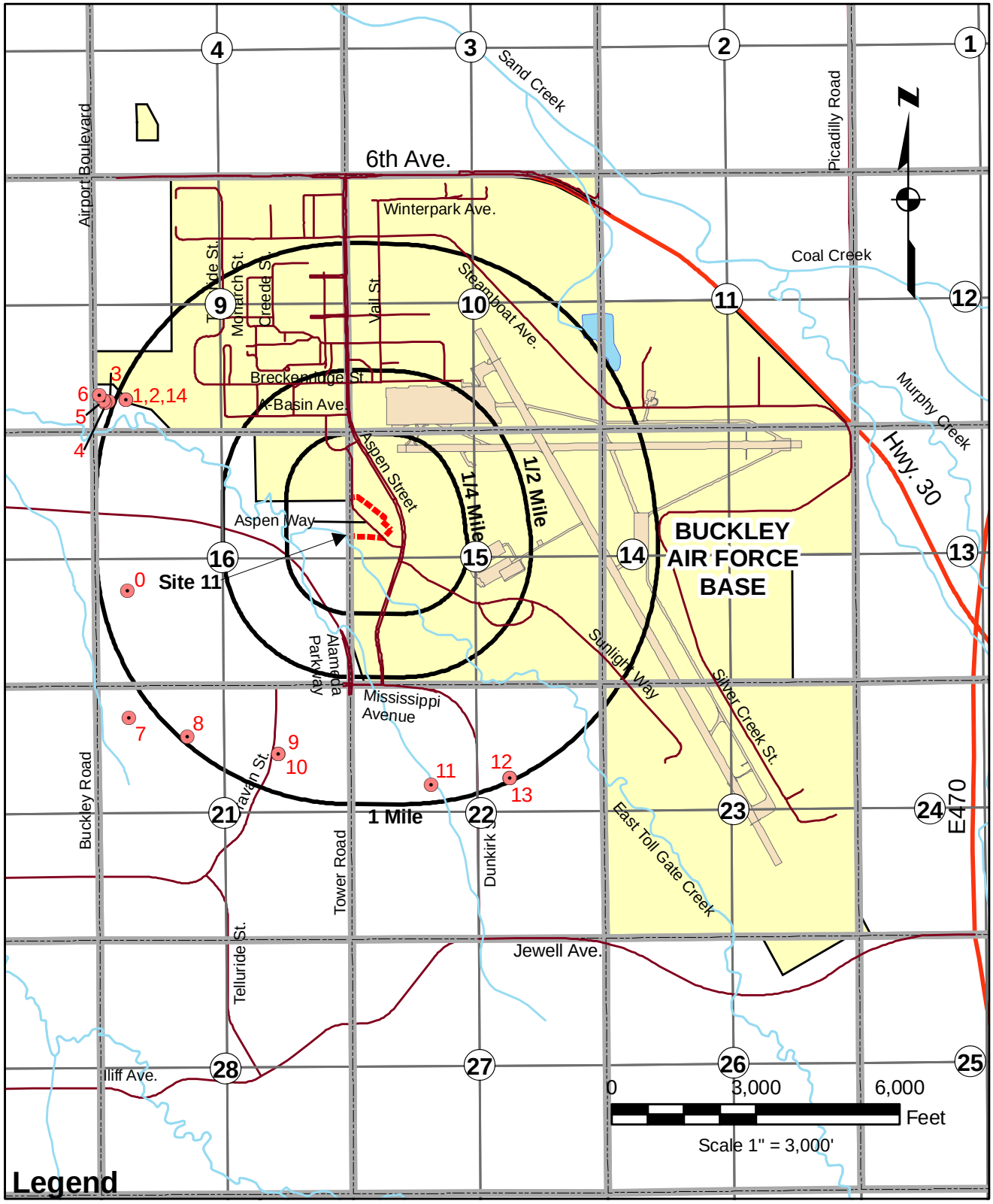
ANALYTE NAME	MDL (µg/L)	RL (µg/L)
1,4-DIOXANE	0.50	1.0
1,1,1,2-TETRACHLOROETHANE	0.25	0.5
1,1,1-TRICHLOROETHANE	0.25	1
1,1,2,2-TETRACHLOROETHANE	0.2	0.5
1,1,2-TRICHLOROETHANE	0.25	1.0
1,1-DICHLOROETHANE	0.125	1.0
1,1-DICHLOROETHENE	0.5	1.0
1,1-DICHLOROPROPENE	0.25	1.0
1,2,3-TRICHLOROBENZENE	0.15	1.0
1,2,3-TRICHLOROPROPANE	0.5	1.0
1,2,4-TRICHLOROBENZENE	0.2	1.0
1,2,4-TRIMETHYLBENZENE	0.25	1.0
1,2-DIBROMO-3-CHLOROPROPANE	1	2
1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.25	1.0
1,2-DICHLOROBENZENE	0.125	1.0
1,2-DICHLOROETHANE	0.25	0.5
1,2-DICHLOROPROPANE	0.2	1.0
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	0.25	1.0
1,3-DICHLOROBENZENE	0.25	1.0
1,3-DICHLOROPROPANE	0.2	0.4
1,4-DICHLOROBENZENE	0.125	0.5
1-CHLOROHEXANE	0.125	1.0
2,2-DICHLOROPROPANE	0.25	1.0
2-CHLOROTOLUENE	0.125	1.0
4-CHLOROTOLUENE	0.25	1.0
ACETONE	2.5	10
BENZENE	0.125	0.4
BROMOBENZENE	0.125	1.0
BROMOCHLOROMETHANE	0.2	1.0
BROMODICHLOROMETHANE	0.25	0.5
BROMOFORM	0.5	1.0
BROMOMETHANE	0.5	3.0
CARBON TETRACHLORIDE	0.25	1.0
CHLOROBENZENE	0.125	0.5
CHLOROETHANE	0.5	1.0

ANALYTE NAME	MDL (µg/L)	RL (µg/L)
CHLOROFORM	0.125	0.3
CHLOROMETHANE	0.5	1.0
CIS-1,2-DICHLOROETHYLENE	0.25	1.0
CIS-1,3-DICHLOROPROPENE	0.25	0.5
DIBROMOCHLOROMETHANE	0.25	0.5
DIBROMOMETHANE	0.25	1.0
DICHLORODIFLUOROMETHANE	0.25	1.0
ETHYLBENZENE	0.25	1.0
HEXACHLOROBUTADIENE	0.25	0.6
ISOPROPYLBENZENE (CUMENE)	0.25	1.0
M,P-XYLENE (SUM OF ISOMERS)	0.5	2.0
METHYL ETHYL KETONE (2-BUTANONE)	2.5	10
METHYL ISOBUTYL KETONE (4-METHYL-2 PENTANONE)	2.5	10
METHYLENE CHLORIDE	0.25	1.0
NAPHTHALENE	0.2	1.0
N-BUTYLBENZENE	0.25	1.0
N-PROPYLBENZENE	0.125	1.0
O-XYLENE (1,2-DIMETHYLBENZENE)	0.25	1.0
P-CYMENE (P-ISOPROPYL TOLUENE)	0.25	1.0
SEC-BUTYLBENZENE	0.25	1.0
STYRENE	0.125	1.0
T-BUTYLBENZENE	0.25	1.0
TERT-BUTYL METHYL ETHER	0.5	1.0
TETRACHLOROETHYLENE (PCE)	0.25	1.0
TOLUENE	0.25	1.0
TRANS-1,2-DICHLOROETHENE	0.25	1.0
TRANS-1,3-DICHLOROPROPENE	0.5	1.0
TRICHLOROETHYLENE (TCE)	0.25	1.0
TRICHLOROFLUOROMETHANE	0.25	1.0
VINYL CHLORIDE	0.25	1.0

MDL – method detection limit
RL – reporting limit
µg/L – micrograms per liter

APPENDIX H

WELL INVENTORY



Off Site Well

Section Line

Initial Site 11 Boundary

Streams

Roads

Note:
Off site well location and information obtained
from Colorado Division of Water Resources AQUAMAP

Figure H-1
Site 11
Off Base Well Locations
Buckley Air Force Base

LocationMap-com&res-wells-9-10.mxd

Table H-1
Well Inventory from Colorado Division of Water Resources
Township 4 South, Range 66 West, Sections 8, 9, 16, 20, 21, and 22
August 2010

Versar RI Map Well #	Permit #	permit suf	status_desc	well_name	ts	tdir	rng	rdir	sec	q160	q40	coordsns	coords ns_dir	coords ew	coords ew_dir	use1	use2	use3	aquifer1_name	date_permit_issued	date_permit_expires	date_well_constructed	date_1st_Beneficial_Use	date_pump_installed	date_well_plugged	comment	elev	well_depth	tperf	bperf	pump_rate	static_water_level	full_name
	66332	F	Permit Issued; Completion Status Unknown	CENTRE HILLS GOND #3	4	S	66	W	8	SE	SE	650	S	1310	E	MUNICIPAL	IRRIGATION		QUATERNARY ALLUVIUM	10/16/2007													AURORA CITY OF
	66331	F	Permit Issued; Completion Status Unknown	CENTRE HILLS GOND #4	4	S	66	W	8	SE	SE	360	S	645	E	MUNICIPAL	IRRIGATION		QUATERNARY ALLUVIUM	10/16/2007													AURORA CITY OF
	18685	MH	Permit Issued; Completion Status Unknown		4	S	66	W	9							OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	2/14/1992	5/14/1992												BUCKLEY AIR NATIONAL GUARD BASE
	224835		Permit Issued; Completion Status Unknown	FMPMW-21	4	S	66	W	9	NE	NE	500	N	325	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	4/6/2000	4/6/2002							0					COLORADO NATIONAL GUARD AGINS/CEV,26
	37249	MH	Permit Issued; Completion Status Unknown		4	S	66	W	9	NE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/1/1999	2/1/2000												BUCKLEY AIR NATIONAL GUARD
	18949	F	Well Constructed		4	S	66	W	9	NW	NW	170	N	420	W	IRRIGATION			ALL UNNAMED AQUIFERS				10/1/1975					1330			75	360	AURORA PUBLIC SCHOOLS
	34074	MH	Permit Issued; Completion Status Unknown		4	S	66	W	9	SE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	7/29/1998	10/29/1998												BUCKLEY AIR NATIONAL GUARD BASE
	26896	F	Permit Canceled	SEE 32059-F	4	S	66	W	9	SE	NE					INDUSTRIAL			ALL UNNAMED AQUIFERS	10/13/1983													US AIR FORCE
	21877	MH	Permit Issued; Completion Status Unknown		4	S	66	W	9	SE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/15/1993	2/15/1994										0		COLORADO AIR NATIONAL GUARD
	25395	F	Permit Expired	SEE 26896-F	4	S	66	W	9	SE	NE					OTHER			ALL UNNAMED AQUIFERS	7/17/1981													US AIR FORCE
	32059	F	Well Constructed		4	S	66	W	9	SE	NE	2690	N	90	E	OTHER		ISSUED PURSUANT	ARAPAHOE	7/28/1987	7/28/1988	11/12/1983	11/14/1983	11/14/1983				1120	900	1060	60	360	US AIR FORCE
	27191	MH	Permit Issued; Completion Status Unknown		4	S	66	W	9	SE	NW					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	12/20/1995	3/20/1996												BUCKLEY ANG BASE
	52353	F	Well Constructed		4	S	66	W	9	SE	NW	2880	N	1810	E	INDUSTRIAL			LOWER ARAPAHOE	8/24/1999	8/24/2000	11/1/1999					5525	1378	1126	1338	175	638	COLORADO AIR NATIONAL GUARD
	14318	AD	Application Denied		4	S	66	W	9	SE	NW	2880	N	1810	E	INDUSTRIAL			ALL UNNAMED AQUIFERS	5/7/1999													COLORADO AIR NATIONAL GUARD
	43214	MH	Well Abandoned	BP-21	4	S	66	W	9	SW	NE	820	S	2210	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	3/10/2004	6/2/2004	3/17/2004			1/12/2004			25	20	25			BUCKLEY DEVELOPMENT INC
	43213	MH	Well Abandoned	BP-1	4	S	66	W	9	SW	NW	1450	S	172	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	3/10/2004	6/2/2004	3/15/2004			1/12/2005			15	10	15			BUCKLEY DEVELOPMENT INC
	43216	MH	Well Abandoned		4	S	66	W	9	SW	SE	220	S	1470	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	3/10/2004	6/2/2004	3/16/2004			1/12/2005			9	4	9			BUCKLEY DEVELOPMENT INC
2	44266	MH	Well Constructed		4	S	66	W	9	SW	SW					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/4/2004	1/26/2005	11/5/2004				5 WELLS		15					SHELL OIL PRODUCTS US
6	265878		Well Constructed	EQ04156MW09	4	S	66	W	9	SW	SW	748	S	107	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/3/2005		8/15/2005				ALSO SEE 265876 &265877		16	6	16			SHELL OIL PRODUCTS US
4	265877		Well Constructed	EQ04156MW08	4	S	66	W	9	SW	SW	600	S	222	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/3/2005		8/15/2005				ALSO SEE 265876 & 265878		15	5	15			SHELL OIL PRODUCTS US
5	44988	MH	Well Constructed	MW-06	4	S	66	W	9	SW	SW	648	S	195	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	5/11/2005	8/8/2005	5/20/2005						15	5	15			SHELL OIL PRODUCTS
3	265876		Well Constructed	EQ04156MW07	4	S	66	W	9	SW	SW	630	S	302	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/3/2005		8/15/2005				ALSO SEE 265877 & 265878		15	5	15			SHELL OIL PRODUCTS US
14	43215	MH	Well Abandoned		4	S	66	W	9	SW	SW	740	S	590	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	3/10/2004	6/2/2004	3/16/2004			1/12/2005			14	9	14			BUCKLEY DEVELOPMENT INC
1	45361	MH	Well Constructed		4	S	66	W	9	SW	SW					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	8/3/2005	10/31/2005	8/19/2005				3 wells- ALSO SEE 265877 & 265878		16	6	16			SHELL OIL PRODUCTS
	48940	MH	Permit Issued; Completion Status Unknown		4	S	66	W	16	NE	SE					OTHER		MONITORING WELL	QUATERNARY ALLUVIUM	11/12/2009	2/17/2010					Ten (10) holes to be constructed							BUCKLEY AIR FORCE
0	47548	DW	Permit Issued; Completion Status Unknown		4	S	66	W	16	SW	NW					OTHER		DEWATERING	DENVER	11/27/2007	2/25/2008					One (1) hole to be constructed							JP TOLLGATE LLC
	260130		Well Constructed	MW12	4	S	66	W	20	NE	NE	400	N	20	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/28/2004		12/3/2002							4	9			HAYNES MIKE
	45057	MH	Permit Issued; Completion Status Unknown		4	S	66	W	20	NE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	5/25/2005	8/23/2005					1191 S Buckley Rd - Aurora							K & G COSCO
	266452		Well Constructed	MW-5R	4	S	66	W	20	NE	NE	463	N	217	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/4/2005		6/10/2005						18	3	18			K & G CONOCO
	41312	MH	Permit Issued; Completion Status Unknown		4	S	66	W	20	NE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/4/2002	1/1/2003					2 WELLS							HAYNES MIKE
	41337	MH	Permit Expired		4	S	66	W	20	NE	NE					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	10/10/2002	1/3/2003					2 WELLS duplicate of 41312-MH no data							HAYNES MIKE
9	46389	MH	Well Constructed	ET-4	4	S	66	W	21	NE	SW	1442	N	1541	E	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	6/27/2006	9/24/2006	7/13/2006						15	5	15		7	AURORA CITY OF
10	276342		Well Constructed	ET-4	4	S	66	W	21	NE	SW	1442	N	1541	E	OTHER		MONITORING WELL	QUATERNARY ALLUVIUM	1/8/2008		7/13/2006					5549	21	5	15		7	AURORA CITY OF
8	46388	MH	Well Constructed	ET-3	4	S	66	W	21	NW	NE	1065	N	1884	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	6/27/2006	9/24/2006	7/28/2006						30	20	30			AURORA CITY OF
8	276343		Well Constructed	ET-3	4	S	66	W	21	NW	NE	1065	N	1884	W	OTHER		MONITORING WELL	QUATERNARY ALLUVIUM	1/8/2008		7/28/2006				DRY HOLE	5601	36	20	30			AURORA CITY OF
7	40522	MH	Permit Expired		4	S	66	W	21	NW	NW					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	2/8/2002	5/6/2002					4 WELLS not constructed per Tom Fox HWS							TCF BANK
	39699	MH	Permit Issued; Completion Status Unknown		4	S	66	W	21	SW	SW					OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	5/15/2001	8/15/2001					3 WELLS							SAFEWAY
	7066	AD	Application Denied		4	S	66	W	22	NE	SW					IRRIGATION			ALL UNNAMED AQUIFERS	12/9/1977													ENVIRONMENTAL DEVELOPERS I
12	1993001	AB	Well Abandoned		4	S	66	W	22	NE	SW					OTHER			ALL UNNAMED AQUIFERS						12/21/1992	3 WELLS 1090 SOUTH HAVANA, AURORA		18					DELTA ENVIRONMENTAL CONSULTANTS
13	7068	AD	Application Denied		4	S	66	W	22	NE	SW					IRRIGATION			ALL UNNAMED AQUIFERS	12/9/1977													ENVIRONMENTAL DEVELOPERS I
	7067	AD	Application Denied		4	S	66	W	22	NE	SW					IRRIGATION			ALL UNNAMED AQUIFERS	12/9/1977													ENVIRONMENTAL DEVELOPERS I
11	46390	MH	Well Constructed	ET-5	4	S	66	W	22	NW	SE	2107	N	1640	W	OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	6/27/2006	9/24/2006	7/12/2006						15	5	15		15	AURORA CITY OF
11	276341		Well Constructed	ET-5	4	S	66	W	22	NW	SE	2107	N	1640	W	OTHER		MONITORING WELL	QUATERNARY ALLUVIUM	1/8/2008		7/12/2006					5569	21	5	15		15	AURORA CITY OF
	18426	MH	Permit Expired		4	S	66	W	22	SE						OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/18/1991	2/16/1992					no data							REGIONAL TRANSPORTATION DIST
	18427	MH	Permit Expired		4	S	66	W	22	SE						OTHER		MONITORING WELL	ALL UNNAMED AQUIFERS	11/18/1991	2/16/1992					no data							CITY ICE COMPANY

WELL SYSTEM DATA FIELDS

Field Header	Definition
receipt	The receipt number is the number assigned when the fee is paid. The entire receipt number is eight numeric characters followed by one alphabetic character (if required).
div (Division)	Numeric identifier for Water Division (1-8) in which the well is located.
cty (County)	Numeric identifier for Colorado counties (1-63) in which the well is located:

COLORADO COUNTIES NUMERICAL CODE:

ADAMS....01
ALAMOSA....02
ARAPAHOE....03
ARCHULETA....04
BACA....05
BENT....06
BOULDER....07
BROOMFIELD....64
CHAFFEE....08
CHEYENNE....09
CLEAR CREEK....10
CONEJOS....11
COSTILLA....12
CROWLEY....13
CUSTER....14
DELTA....15
DENVER....16
DOLORES....17
DOUGLAS....18
EAGLE....19
ELBERT....20
EL PASO....21
FREMONT....22
GARFIELD....23
GILPIN....24
GRAND....25
GUNNISON....26
HINSDALE....27
HUERFANO....28
JACKSON....29
JEFFERSON....30
KIOWA....31
KIT CARSON....32
LAKE....33
LA PLATA....34
LARIMER....35
LAS ANIMAS....36
LINCOLN....37
LOGAN....38
MESA....39
MINERAL....40
MOFFAT....41
MONTEZUMA....42
MONTROSE....43
MORGAN....44
OTERO....45
OURAY....46
PARK....47
PHILLIPS....48
PITKIN....49
PROWERS....50
PUEBLO....51
RIO BLANCO....52
RIO GRANDE....53
ROUTT....54
SAGUACHE....55
SAN JUAN....56
SAN MIGUEL....57
SEDGWICK....58
SUMMIT....59
TELLER....60
WASHINGTON....61
WELD....62
YUMA....63

permitno (Permit Number)	The well permit number (numeric).
permitsuf (Permit Suffix)	A character field for the well suffix code that follows the permit number.
Permitrpl	Identifier indicating a well's replacement.
actdate	Date well permit application received.

actcode The activity code states status of permit application file:

Code	*Desc*
AP =	New application received.
AD =	Application denied. Denial number entered in permit number field and date entered in permit issued date field.
AW =	Application for a permit is withdrawn. Code and date also entered to status code and date fields.
AV =	Verbal approval granted to well construction contractor to construct a well without a permit in place (emergency only).
CA =	Canceled well permit. Code and date also entered to status code and date fields.
CD =	Change description of acres irrigated (designated basins). Entered to status and date fields of existing record upon receipt of application.
CO =	Application to commingle wells (designated basins). Entered to status and date fields of existing record upon receipt of application.
CP =	Amended household use permit to allow watering of user's noncommercial domestic animals.
EX =	Well permit expiration date extended.
MH =	Monitoring hole notice of construction. MH file number and date entered in permit number and permit date fields.
NP =	Well permit issued. Permit number and issue date entered in permit number and permit date fields.
TH =	Test hole notice. Replaced by MH notice in 1988.
TW =	Test well. Replaced by MH notice in 1988.

wd A character field which indicates the Water District in which the well is located (1-80). Defined as a basin on minor drainage within the Water Division.

basin When applicable, a character field indicating the Designated Groundwater Basin Number (1-8):

DESIGNATED BASINS

NORTHERN HIGH PLAINS	01
KIOWA-BIJOU	02
SOUTHERN HIGH PLAINS	03
UPPER BLACK SQUIRREL CREEK	04
LOST CREEK	05
CAMP CREEK	06
UPPER BIG SANDY	07
UPPER CROW CREEK	08

md A character field indicating the Designated Groundwater Basin Management District Number (1-13):

MANAGEMENT DISTRICTS (BASINS)

PLAINS	01
SAND HILLS	02
ARIKAREE	03
FRENCHMAN	04
CENTRAL YUMA	05
W – Y	06
NORTH KIOWA-BIJOU	07
EASTERN CHEYENNE	08
LOST CREEK	09
SOUTHERH HIGH PLAINS	10
MARKS BUTTE	11
UPPER BLACK SQUIRREL	12
UPPER BIG SANDY	13

full name	Applicant name (character field).
address1	A character field for the street portion of the primary mailing address of the permit holder.
address2	A character field for the street portion of a secondary mailing address if submitted.
city	A character field for the City of the primary mailing address.
state	A character field for the State of the primary mailing address
zip1	A character field for the primary zip code.
zip2	A character field for a secondary zip code, if provided.
phone_number	A character field for Applicant's phone number.
pm	Principal Meridian in which well is located (S = Sixth, N = New Mexico, U = Ute, C = Costilla, B = Baca).
rng (Range)	Numeric field for the Range in which well is located.
Rnga	Identifies half ranges (“H”)
Rdir	Identifies direction (E, W)
ts (Township)	Numeric field for Township in which well is located.
Tsa	Identifies half ranges (“H”)
Tdir	Identifies direction (N, S)
sec (Section)	Numeric field for Section in which well is located (1-36).
Seca	Reserved for locations containing a U in the section number.
QTR160	Character field for quarter section (160 acre quarter) in which well is located.
QTR40	Character field for the quarter-quarter section (40 acre quarter of 160 acre quarter) in which well is located.
QTR10	Character field for the quarter-quarter section (10 acre quarter of 40 acre quarter) in which well is located.
coordsns	Distance (feet) from the north or south section line to the well location.
coordsns_dir	Identifies which section line (N,S) from which distance is measured.
coordsew	Distance (feet) from the east or west section line to the well location.
coordsew_dir	Identifies which section line (E,W) from which distance is measured.

AQUIFER1 Aquifer in which well is located.

AQUIFER CODES:

GW	ALL UNNAMED AQUIFERS	
KA	ARAPAHOE	
UKA	UPPER ARAPAHOE	
LKA	LOWER ARAPAHOE	
JMB	BRUSHY BASIN	
KDB	BURRO CANYON	
KCH	CHEYENNE	
CON	CONFINED	SAN LUIS VALLEY
KD	DAKOTA	
TDW	DAWSON	
UTDW	UPPER DAWSON	
LTDW	LOWER DAWSON	
TKD	DENVER	
JE	ENTRADA	
TG	GREEN RIVER	
PH	HERMOSA	
KI	ILES	
KL	LARAMIE	
KLF	LARAMIE FOX HILLS	
ML	LEADVILLE LIMESTONE	
KM	MANCOS	
KMV	MESA VERDE GROUP	
JM	MORRISON	
TO	OGALLALA	
KP	PIERRE SHALE	
KPU	PURGATOIRE	
JMS	SALT WASH	
UNC	UNCONFINED	SAN LUIS VALLEY
TW	WASATCH	
TW	WHITE RIVER	
KW	WILLIAMS FORK	

AQUIFER2 name of second aquifer if well is known to be multiply completed.

subdiv_name Subdivision name.

lot Lot number in subdivision.

block Block number in subdivision.

filing Filing number.

engineer Engineer who approved permit.

well_name Owners's well designation number or name.

Use1 & Use2 Codes for well Uses:

Data Code	Use Description
1	Crop Irrigation
2	Municipal
3	COMMERCIAL
4	INDUSTRIAL
5	RECREATION
6	FISHERY
7	FIRE
8	DOMESTIC
9	LIVESTOCK
G	GEOTHERMAL
H	HOUSEHOLD USE ONLY
K	SNOWMAKING
O	OTHER
O	MONITORING HOLE/WELL
R	RECHARGE
E	EXCHANGE AND AUGMENTATION
Q	=O (Other, or Monitoring Hole/Well)

Use3

CODE	TYPE
A	AUGMENTATION. All wells in augmentation plans are coded with an "A" in the last position. First position is the actual use of the well.
M	MONITORING WELL (PERMITTED). The first position is "O" followed by "M" in the last position.
Z	HOUSEHOLD USE WELLS ISSUED PRIOR TO HB1111 THAT HAVE BEEN AMENDED PURSUANT TO (3)(b)(II)(b) BY $25.00 APPLICATION. First position code is "H" followed by "Z" in the last position.
L	PERMIT ISSUED UNDER PRESUMPTION (3)(b)(II)(A) FOR DOMESTIC/LIVESTOCK USES AS THE ONLY WELL ON 35 ACRES. First position is either "8" domestic or "9" livestock", or both 1st and 2nd followed by "L" in the last position. PERMITS ISSUED UNDER (3)(b)(I) WHERE WATER IS AVAILABLE ARE CODED FIRST POSITIONS AS NECESSARY WITH THE ACTUAL USE. HB1111 does not apply to these wells.
G	GRAVEL PIT WELL PERMIT. This application (PERMIT) is coded as "O" in the first position with "G" in the last position.
C	CLOSED LOOP GEOTHERMAL WELL. First position is codes as "G" for geothermal. Last position is "C".
P	GEOTHERMAL PRODUCTION WELL. First position is coded "G" for geothermal. Last position is "P".
S	OTHER TYPES OF HOLES CONSTRUCTED-ESPECIALLY FOR CATHODIC PROTECTION. IDENTIFIES THAT THE PERMIT WAS ISSUED PURSUANT TO SENATE BILL 5 (137 (4). First positions are for the actual use(s) of the well.

driller_lic Water well contractor's license number.

pump_lic Pump installation contractor's license number.

pidate Date the pump installation report is received by DWR.

statute Statute under which the permit was issued using the last four numbers of chapter and paragraph, i.e. 37-92-602(3)..602(3). (see www.intellinetusa.com/statmgr.htm)

statcode Interim status of the application or permit:

Code	*Desc*
AB =	Abandoned well.
AR =	Date application for permit resubmitted to DWR.
AU =	Date application returned to applicant for correction or additional information.
EP =	Expired well permit.
NS =	Exempt wells where no statement of use is required (no longer used).
PI =	Pump Installation Report received (no longer used).
PU =	Pump Installation Report returned to responsible party for correction.
RC =	Record change. A portion of the file was modified.
SA =	Statement of beneficial use accepted (no longer used in statute code).
SP =	Statement of beneficial use received (no longer used in statute code).
SR =	Statement of beneficial use resubmitted to DWR.
SU =	Statement of beneficial use returned to owner for correction.
WA =	Well construction report received (no longer used).
WU =	Well construction report returned to responsible party for correction.
WR =	Well construction report resubmitted to DWR.
ZZ =	Transaction code indicates a portion of the file was updated with general review and update of records.

statdate Date of the above status code action.

npdate Date the permit, denial (AD) or monitoring hole was issued.

wadate Date the Well Construction and Test Report was received in DWR.

trancode Activity or status code. Last action updated.

trandate Computer machine date of last update to the record.

sadate	Date of first beneficial use.
sbudate	Date statement of use received.
exdate	Expiration date of well permit.
abrdate	Date abandonment report received.
abcodate	Date well plugged and abandoned.
abreq	Flag if the well requires plugging and sealing upon construction of new well
acreft	Annual appropriation in acre feet.
tperf	Depth to top of first perforated casing.
bperf	Depth to base of last perforated casing.
case_no	Water court case number.
yield	Yield in gallons per minute.
depth	Total depth of well.
level	Depth to static water level.
elev	Ground surface elevation.
area_irr	Acres irrigated.
Irr_meas	Acre irrigated units
comment	Comment field
meter	Totalizing flow meter reqd., installed.
wellxno	Cross reference to another well or record.
Wellxsuf	Cross reference character field for well suffix code (follows the permit number).
Wellxrpl	Cross reference identifier indicates well replacement.
Nwcdate	Notice of Well Construction Report received (Statewide nontributary rules).
Nbudate	Notice of Commencement of Beneficial Use received (Statewide nontributary rules).
wcdate	Date well construction completed.
pcdate	Date pump installation completed
log	Flag to indicate if a geophysical is required and received.
qual	Water quality information available, y or n.
user1	Initials of last staff member to update file.
pyield	Proposed yield of well in gpm.

pdepth	Proposed depth of well.
pacreft	Proposed annual appropriation.
well_type	Calculated value to determine if record is exempt, non exempt or georthermal.
valid_permit	Calculated value to determine if a well permit is valid. (must be verified)
parcel_no	Parcel identifier
parcel_size	Parcel size in acres. Number of acres on well site.
noticedate	Notice sent to owner indicating permit about to expire. (Not yet used)
utm_x	A numeric field for the UTM-X coordinate. All UTM values are Zone 13 based on NAD83.
utm_y	A numeric field for the UTM-X coordinate. All UTM values are Zone 13 based on NAD83.
loc_source	Identifies source of UTM coordinates. If the location was obtained from the PLSS location, it is indicated by the description “SPOTTED”.

d:documents/word.Well_data fields.doc (6/25/01, ebt)
Modified from wellsys.doc 1/27/97 rab.
`c:officedoc.wellsys.doc`

APPENDIX I

RISK EVALUATION TABLES

APPENDIX I
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Table I-1
Dermally Absorbed Dose per Event (DAevent) Calculations
Resident Exposure to Groundwater from On-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Note	Chemical Concentration Cw (mg/cm^3)	Fraction Absorbed FA (dimensionless)	Permeability Coefficient Kp (cm/hr)	Lag time per event τevent (hr)	Permeability Ratio B (dimensionless)	Time to reach steady-state t* (hr)	Resident, Adult				
								Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Bromodichloromethane	a	7.21E-07	1.0	4.60E-03	0.88	0.0	2.12	0.58	Yes	6.57E-09	5.55E-07	1.62E-06
Carbon Tetrachloride	a	2.83E-07	1.0	1.60E-02	0.78	0.1	1.86	0.58	Yes	8.44E-09	7.14E-07	2.08E-06
Chloroform	a	1.15E-06	1.0	6.80E-03	0.5	0.0	1.19	0.58	Yes	1.17E-08	9.87E-07	2.88E-06
Naphthalene	a	4.19E-07	1.0	4.70E-02	0.56	0.2	1.34	0.58	Yes	3.11E-08	2.63E-06	7.66E-06
Tetrachloroethene	a	1.09E-04	1.0	3.30E-02	0.2	2.18	0.91	0.58	Yes	3.38E-06	2.86E-04	8.34E-04
Trichloroethene	a	4.16E-06	1.0	1.20E-02	0.58	0.10	1.39	0.58	Yes	8.03E-08	6.78E-06	1.98E-05

COPC	Note	Resident, Child				
		Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Bromodichloromethane	a	1.00E+00	Yes	8.60E-09	3.11E-07	3.63E-06
Carbon Tetrachloride	a	1.00E+00	Yes	1.11E-08	4.00E-07	4.66E-06
Chloroform	a	1.00E+00	Yes	1.53E-08	5.53E-07	6.45E-06
Naphthalene	a	1.00E+00	Yes	4.07E-08	1.47E-06	1.72E-05
Tetrachloroethene	a	1.00E+00	No	4.22E-06	1.53E-04	1.78E-03
Trichloroethene	a	1.00E+00	Yes	1.05E-07	3.80E-06	4.43E-05

Notes:
a - Source: EPA, 2004 - Risk Assessment Guidance for Superfund (RAGS), Part E - Values from Exhibit B-3, Calculation of Dermal Absorbed Dose for Organic Chemicals in Water.

cm/hr - centimeters per hour
COPC = Chemical of Potential Concern
hr - hour
mg/cm^2 = milligrams per square centimeter
mg/cm^3 = milligrams per cubic centimeter
mg/kg - milligrams per kilogram.

Table I-2
Dermally Absorbed Dose per Event (DAevent) Calculations
Resident and Construction Worker Exposure to Groundwater from Off-Base PCE Plume
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Note	Chemical Concentration Cw (mg/cm^3)	Fraction Absorbed FA (dimensionless)	Permeability Coefficient Kp (cm/hr)	Lag time per event τevent (hr)	Permeability Ratio B (dimensionless)	Time to reach steady-state t* (hr)	Resident, Adult				
								Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Tetrachloroethene	a	2.20E-05	1.0	3.30E-02	0.2	2.18	0.91	0.58	Yes	6.85E-07	5.79E-05	1.69E-04
Trichloroethene	a	9.38E-05	1.0	1.20E-02	0.58	0.10	1.39	0.58	Yes	1.81E-06	1.53E-04	4.46E-04

COPC	Note	Resident, Child					Construction Worker, Adult				
		Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)	Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Tetrachloroethene	a	1.00E+00	No	8.54E-07	3.09E-05	3.60E-04	2.00E+00	No	1.08E-06	4.99E-07	3.50E-05
Trichloroethene	a	1.00E+00	Yes	2.37E-06	8.57E-05	1.00E-03	2.00E+00	No	3.48E-06	1.61E-06	1.12E-04

Notes:
a - Source: EPA, 2004 - Risk Assessment Guidance for Superfund (RAGS), Part E - Values from Exhibit B-3, Calculation of Dermal Absorbed Dose for Organic Chemicals in Water.

cm/hr - centimeters per hour
COPC = Chemical of Potential Concern
hr - hour
mg/cm^2 = milligrams per square centimeter
mg/cm^3 = milligrams per cubic centimeter
mg/kg - milligrams per kilogram.

Table I-3
Dermally Absorbed Dose per Event (DAevent) Calculations
Visitor and Maintenance Worker Exposure to Surface Water from East Toll Gate Creek
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Note	Chemical Concentration Cw (mg/cm^3)	Fraction Absorbed FA (dimensionless)	Permeability Coefficient Kp (cm/hr)	Lag time per event τevent (hr)	Permeability Ratio B (dimensionless)	Time to reach steady-state t* (hr)	Visitor, Youth				
								Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Tetrachloroethene	a	4.70E-07	1.0	3.30E-02	0.2	2.18	0.91	1.00E+00	No	1.83E-08	1.08E-08	1.26E-07

COPC	Note	Maintenance Worker, Adult				
		Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
Tetrachloroethene	a	2.00E+00	No	2.31E-08	1.28E-08	3.83E-08

Notes:
a - Source: EPA, 2004 - Risk Assessment Guidance for Superfund (RAGS), Part E - Values from Exhibit B-3, Calculation of Dermal Absorbed Dose for Organic Chemicals in Water.

cm/hr = centimeters per hour
COPC = Chemical of Potential Concern
hr = hour
mg/cm^2 = milligrams per square centimeter
mg/cm^3 = milligrams per cubic centimeter
mg/kg = milligrams per kilogram.

Table I-4
Dermally Absorbed Dose per Event (DAevent) Calculations
Resident Exposure to Groundwater from North Plume
Site 11 RI, Buckley Air Force Base, Colorado

COPC	Note	Chemical Concentration Cw (mg/cm^3)	Fraction Absorbed FA (dimensionless)	Permeability Coefficient Kp (cm/hr)	Lag time per event τevent (hr)	Permeability Ratio B (dimensionless)	Time to reach steady-state t* (hr)	Resident, Adult				
								Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
1,2-Dichloroethane	a	1.40E-04	1.0	4.20E-03	0.38	0.0	0.92	0.58	Yes	7.65E-07	6.47E-05	1.89E-04
Carbon tetrachloride	a	9.38E-05	1.0	1.60E-02	0.78	0.1	1.86	0.58	Yes	2.80E-06	2.37E-04	6.90E-04
Chloroform	a	6.02E-06	1.0	6.80E-03	0.5	0.0	1.19	0.58	Yes	6.11E-08	5.17E-06	1.51E-05
Naphthalene	a	2.40E-07	1.0	4.70E-02	0.56	0.2	1.34	0.58	Yes	1.78E-08	1.51E-06	4.39E-06
Trichloroethene	a	6.58E-05	1.0	1.20E-02	0.58	0.10	1.39	0.58	Yes	1.27E-06	1.07E-04	3.13E-04

COPC	Note	Resident, Child				
		Event time tevent (hr/event)	Is tevent < t*?	Absorb. Dose DAevent (mg/cm^2-event)	DADc (mg/kg-day)	DADnc (mg/kg-day)
1,2-Dichloroethane	a	1.00E+00	No	1.03E-06	3.74E-05	4.37E-04
Carbon tetrachloride	a	1.00E+00	Yes	3.66E-06	1.32E-04	1.55E-03
Chloroform	a	1.00E+00	Yes	8.00E-08	2.89E-06	3.38E-05
Naphthalene	a	1.00E+00	Yes	2.33E-08	8.44E-07	9.84E-06
Trichloroethene	a	1.00E+00	Yes	1.66E-06	6.01E-05	7.01E-04

Notes:
a - Source: EPA, 2004 - Risk Assessment Guidance for Superfund (RAGS), Part E - Values from Exhibit B-3, Calculation of Dermal Absorbed Dose for Organic Chemicals in Water.

cm/hr - centimeters per hour
COPC = Chemical of Potential Concern
hr - hour
mg/cm^2 = milligrams per square centimeter
mg/cm^3 = milligrams per cubic centimeter
mg/kg - milligrams per kilogram.

Table I-5
Risks to Future Commercial Workers
On-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Bromodichloromethane	7.21E-01	5.04E-06	6.20E-02	3.12E-07	1.41E-05	2.00E-02	7.05E-04
Carbon tetrachloride	2.83E-01	1.98E-06	7.00E-02	1.38E-07	5.54E-06	4.00E-03	1.38E-03
Chloroform	1.15E+00	8.04E-06	3.10E-02	2.49E-07	2.25E-05	1.00E-02	2.25E-03
Naphthalene	4.19E-01	2.92E-06	--	-	8.19E-06	2.00E-02	4.09E-04
Tetrachloroethene	1.09E+02	7.59E-04	5.40E-01	**4.10E-04**	2.13E-03	1.00E-02	2.13E-01
Trichloroethene	4.16E+00	2.91E-05	5.90E-03	1.72E-07	8.14E-05	-	-
			Carcinogenic Risk	**4.11E-04**		**Hazard Index**	2.17E-01

INHALATION - INDOOR VAPOR FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk $(ug/m^3)^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Bromodichloromethane	1.94E-03	1.58E-04	3.70E-05	5.85E-09	4.42E-07	--	-
Carbon tetrachloride	2.00E-02	1.63E-03	6.00E-06	9.80E-09	4.57E-06	1.00E-01	4.57E-05
Chloroform	1.31E-02	1.07E-03	2.30E-05	2.46E-08	2.99E-06	9.80E-02	3.05E-05
Naphthalene	1.66E-02	1.35E-03	3.40E-05	4.60E-08	3.78E-06	3.00E-03	1.26E-03
Tetrachloroethene	2.64E+00	2.15E-01	5.90E-06	**1.27E-06**	6.02E-04	2.70E-01	2.23E-03
Trichloroethene	3.54E-03	2.89E-04	2.00E-06	5.77E-10	8.08E-07	--	-
			Carcinogenic Risk	**1.36E-06**		**Hazard Index**	3.57E-03
	Total Carcinogenic Risk - Groundwater Exposure			**4.12E-04**	**Total HI - Groundwater Exposure**		2.21E-01

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$µg/m^3$ = micrograms per cubic meter

Table I-6
Risks to Future Construction Workers
On-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INHALATION OF VAPORS IN TRENCH - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Trench Air (ug/m^3)**	**Exposure Concentration (ug/m^3)**	**Inhalation Unit Risk $(ug/m^3)^{-1}$**	**Risk Probability**	**Exposure Concentration (mg/m^3)**	**Reference Concentration (mg/m^3)**	**Hazard Quotient**
Bromodichloromethane	1.74E-02	1.37E-05	3.70E-05	5.05E-10	1.91E-06	--	-
Carbon tetrachloride	2.00E-02	1.57E-05	6.00E-06	9.41E-11	2.20E-06	1.00E-01	2.20E-05
Chloroform	1.18E-01	9.23E-05	2.30E-05	2.12E-09	1.29E-05	9.80E-02	1.32E-04
Naphthalene	3.21E-03	2.51E-06	3.40E-05	8.54E-11	3.52E-07	3.00E-03	1.17E-04
Tetrachloroethene	3.87E+01	3.03E-02	5.90E-06	1.79E-07	4.24E-03	2.70E-01	1.57E-02
Trichloroethene	9.10E-01	7.12E-04	2.00E-06	1.42E-09	9.97E-05	--	-
			Carcinogenic Risk	1.83E-07		**Hazard Index**	1.60E-02
			Total Carcinogenic Risk - Groundwater Exposure	1.83E-07		**Total HI - Groundwater Exposure**	1.60E-02

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
$\mu g/m^3$ = micrograms per cubic meter

Table I-7
Risks to Future Adult Residents
On-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Groundwater (ug/L)**	**Lifetime Average Daily Dose (mg/kg/day)**	**Oral Slope Factor (kg-day/mg)**	**Risk Probability**	**Chronic Daily Intake (mg/kg/day)**	**Oral Reference Dose (mg/kg/day)**	**Hazard Quotient**
Bromodichloromethane	7.21E-01	6.77E-06	6.20E-02	4.20E-07	1.98E-05	2.00E-02	9.88E-04
Carbon tetrachloride	2.83E-01	2.66E-06	7.00E-02	1.86E-07	7.75E-06	4.00E-03	1.94E-03
Chloroform	1.15E+00	1.08E-05	3.10E-02	3.35E-07	3.15E-05	1.00E-02	3.15E-03
Naphthalene	4.19E-01	3.93E-06	--	-	1.15E-05	2.00E-02	5.73E-04
Tetrachloroethene	1.09E+02	1.02E-03	5.40E-01	**5.51E-04**	2.98E-03	1.00E-02	2.98E-01
Trichloroethene	4.16E+00	3.91E-05	5.90E-03	2.31E-07	1.14E-04	-	-
			Carcinogenic Risk	**5.52E-04**		**Hazard Index**	3.04E-01

DERMAL CONTACT - GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Groundwater (ug/L)**	**Dermally Absorbed Dose (mg/kg/day)**	**Oral Slope Factor (kg-day/mg)**	**Risk Probability**	**Dermally Absorbed Dose (mg/kg/day)**	**Oral Reference Dose (mg/kg/day)**	**Hazard Quotient**
Bromodichloromethane	7.21E-01	5.55E-07	6.20E-02	3.44E-08	1.62E-06	2.00E-02	8.10E-05
Carbon tetrachloride	2.83E-01	7.14E-07	7.00E-02	5.00E-08	2.08E-06	4.00E-03	5.20E-04
Chloroform	1.15E+00	9.87E-07	3.10E-02	3.06E-08	2.88E-06	1.00E-02	2.88E-04
Naphthalene	4.19E-01	2.63E-06	--	-	7.66E-06	2.00E-02	3.83E-04
Tetrachloroethene	1.09E+02	2.86E-04	5.40E-01	**1.54E-04**	8.34E-04	1.00E-02	8.34E-02
Trichloroethene	4.16E+00	6.78E-06	5.90E-03	4.00E-08	1.98E-05	-	-
			Carcinogenic Risk	**1.55E-04**		**Hazard Index**	8.47E-02

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Indoor Air (ug/m^3)**	**Exposure Concentration (ug/m^3)**	**Inhalation Unit Risk $(ug/m^3)^{-1}$**	**Risk Probability**	**Exposure Concentration (mg/m^3)**	**Reference Concentration (mg/m^3)**	**Hazard Quotient**
Bromodichloromethane	1.94E-03	6.37E-04	3.70E-05	2.36E-08	1.86E-06	--	-
Carbon tetrachloride	2.00E-02	6.59E-03	6.00E-06	3.95E-08	1.92E-05	1.00E-01	1.92E-04
Chloroform	1.31E-02	4.31E-03	2.30E-05	9.91E-08	1.26E-05	9.80E-02	1.28E-04
Naphthalene	1.66E-02	5.45E-03	3.40E-05	1.85E-07	1.59E-05	3.00E-03	5.30E-03
Tetrachloroethene	2.64E+00	8.68E-01	5.90E-06	**5.12E-06**	2.53E-03	2.70E-01	9.37E-03
Trichloroethene	3.54E-03	1.16E-03	2.00E-06	2.33E-09	3.39E-06	--	-
			Carcinogenic Risk	**5.47E-06**		**Hazard Index**	1.50E-02
		Total Carcinogenic Risk - Groundwater Exposure		**7.12E-04**	**Total HI - Groundwater Exposure**		4.04E-01

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$\mu g/m^3$ = micrograms per cubic meter

Table I-8
Risks to Future Child Residents
On-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION OF GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Bromodichloromethane	7.21E-01	3.95E-06	6.20E-02	2.45E-07	4.61E-05	2.00E-02	2.30E-03
Carbon tetrachloride	2.83E-01	1.55E-06	7.00E-02	1.09E-07	1.81E-05	4.00E-03	4.52E-03
Chloroform	1.15E+00	6.30E-06	3.10E-02	1.95E-07	7.35E-05	1.00E-02	7.35E-03
Naphthalene	4.19E-01	2.29E-06	--	-	2.68E-05	2.00E-02	1.34E-03
Tetrachloroethene	1.09E+02	5.95E-04	5.40E-01	**3.21E-04**	6.94E-03	1.00E-02	6.94E-01
Trichloroethene	4.16E+00	2.28E-05	5.90E-03	1.34E-07	2.66E-04	-	-
			Carcinogenic Risk	**3.22E-04**		**Hazard Index**	7.10E-01

DERMAL CONTACT WITH GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Dermally Absorbed Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Dermally Absorbed Dose (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Bromodichloromethane	7.21E-01	3.11E-07	6.20E-02	1.93E-08	3.63E-06	2.00E-02	1.81E-04
Carbon tetrachloride	2.83E-01	4.00E-07	7.00E-02	2.80E-08	4.66E-06	4.00E-03	1.17E-03
Chloroform	1.15E+00	5.53E-07	3.10E-02	1.71E-08	6.45E-06	1.00E-02	6.45E-04
Naphthalene	4.19E-01	1.47E-06	--	-	1.72E-05	2.00E-02	8.58E-04
Tetrachloroethene	1.09E+02	1.53E-04	5.40E-01	**8.24E-05**	1.78E-03	1.00E-02	1.78E-01
Trichloroethene	4.16E+00	3.80E-06	5.90E-03	2.24E-08	4.43E-05	-	-
			Carcinogenic Risk	**8.24E-05**		**Hazard Index**	1.81E-01

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk (ug/m^3)$^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Bromodichloromethane	1.94E-03	1.59E-04	3.70E-05	5.89E-09	1.86E-06	--	-
Carbon tetrachloride	2.00E-02	1.65E-03	6.00E-06	9.88E-09	1.92E-05	1.00E-01	1.92E-04
Chloroform	1.31E-02	1.08E-03	2.30E-05	2.48E-08	1.26E-05	9.80E-02	1.28E-04
Naphthalene	1.66E-02	1.36E-03	3.40E-05	4.63E-08	1.59E-05	3.00E-03	5.30E-03
Tetrachloroethene	2.64E+00	2.17E-01	5.90E-06	**1.28E-06**	2.53E-03	2.70E-01	9.37E-03
Trichloroethene	3.54E-03	2.91E-04	2.00E-06	5.82E-10	3.39E-06	--	-
			Carcinogenic Risk	**1.37E-06**		**Hazard Index**	1.50E-02
			Total Carcinogenic Risk - Groundwater Exposure	**4.06E-04**		**Total HI - Groundwater Exposure**	9.06E-01

Notes:
Values in **bold** indicate a cancer risk >1x10^{-6} or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table I-9
Risks to Current/Future Maintenance Workers
Off-Base Surface Water
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION OF SURFACE WATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Surface Water (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	4.70E-01	3.94E-10	5.40E-01	2.13E-10	1.10E-09	1.00E-02	1.10E-07
			Carcinogenic Risk	2.13E-10		**Hazard Index**	1.10E-07

DERMAL CONTACT WITH SURFACE WATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Surface Water (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	4.70E-01	1.28E-08	5.40E-01	6.91E-09	3.83E-08	1.00E-02	3.83E-06
			Carcinogenic Risk	6.91E-09		**Hazard Index**	3.83E-06
			Total Carcinogenic Risk - Surface Water	7.13E-09		**Total HI - Surface Water**	3.94E-06

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table I-10
Risks to Future Construction Workers
Off-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	22	1.48E-08	5.40E-01	7.97E-09	2.07E-06	1.00E-02	2.07E-04
Trichloroethene	4.4	2.95E-09	5.90E-03	1.74E-11	4.13E-07	-	-
			Carcinogenic Risk	7.99E-09		**Hazard Index**	2.07E-04

DERMAL CONTACT - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Dermally Absorbed Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Dermally Absorbed Dose (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	2.20E+01	1.20E-07	5.40E-01	6.47E-08	1.68E-05	1.00E-02	1.68E-03
Trichloroethene	4.40E+00	3.85E-07	5.90E-03	2.27E-09	5.40E-05	-	-
			Carcinogenic Risl	6.70E-08		**Hazard Index**	1.68E-03

INHALATION OF VAPORS IN TRENCH - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Trench Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk $(ug/m^3)^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Tetrachloroethene	1.42E+02	1.11E-01	5.90E-06	6.57E-07	1.56E-02	2.70E-01	5.77E-02
Trichloroethene	3.19E+01	2.50E-02	2.00E-06	4.99E-08	3.49E-03	--	-
			Carcinogenic Risl	7.07E-07		**Hazard Index**	5.77E-02
		Total Carcinogenic Risk - Groundwater Exposure		7.82E-07	**Total HI - Groundwater Exposure**		5.96E-02

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$µg/m^3$ = micrograms per cubic meter

Table I-11
Risks to Future Adult Residents
Off-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Groundwater (ug/L)**	**Lifetime Average Daily Dose (mg/kg/day)**	**Oral Slope Factor (kg-day/mg)**	**Risk Probability**	**Chronic Daily Intake (mg/kg/day)**	**Oral Reference Dose (mg/kg/day)**	**Hazard Quotient**
Tetrachloroethene	22	2.07E-04	5.40E-01	**1.12E-04**	6.03E-04	1.00E-02	6.03E-02
Trichloroethene	4.4	4.13E-05	5.90E-03	2.44E-07	1.21E-04	-	-
			Carcinogenic Risk	**1.12E-04**		**Hazard Index**	6.03E-02

DERMAL CONTACT - GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Groundwater (ug/L)**	**Dermally Absorbed Dose (mg/kg/day)**	**Oral Slope Factor (kg-day/mg)**	**Risk Probability**	**Dermally Absorbed Dose (mg/kg/day)**	**Oral Reference Dose (mg/kg/day)**	**Hazard Quotient**
Tetrachloroethene	22	5.79E-05	5.40E-01	**3.13E-05**	1.69E-04	1.00E-02	1.69E-02
Trichloroethene	4.4	1.53E-04	5.90E-03	9.03E-07	4.46E-04	-	-
			Carcinogenic Risk	**3.22E-05**		**Hazard Index**	1.69E-02

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER

		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Indoor Air (ug/m^3)**	**Exposure Concentration (ug/m^3)**	**Inhalation Unit Risk $(ug/m^3)^{-1}$**	**Risk Probability**	**Exposure Concentration (mg/m^3)**	**Reference Concentration (mg/m^3)**	**Hazard Quotient**
Tetrachloroethene	3.28E+00	1.08E+00	5.90E-06	**6.35E-06**	3.14E-03	2.70E-01	1.16E-02
Trichloroethene	4.39E-01	1.44E-01	2.00E-06	2.89E-07	4.21E-04	--	-
			Carcinogenic Risk	**6.64E-06**		**Hazard Index**	1.16E-02
		Total Carcinogenic Risk - Groundwater Exposure		**1.51E-04**	**Total HI - Groundwater Exposure**		8.88E-02

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$µg/m^3$ = micrograms per cubic meter

Table I-12
Risks to Future Child Residents
Off-Base PCE Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION OF GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	22	1.21E-04	5.40E-01	**6.51E-05**	1.41E-03	1.00E-02	1.41E-01
Trichloroethene	4.4	2.41E-05	5.90E-03	1.42E-07	2.81E-04	-	-
			Carcinogenic Risk	**6.52E-05**		**Hazard Index**	1.41E-01

DERMAL CONTACT WITH GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Dermally Absorbed Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Dermally Absorbed Dose (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	22	3.09E-05	5.40E-01	**1.67E-05**	3.60E-04	1.00E-02	3.60E-02
Trichloroethene	4.4	8.57E-05	5.90E-03	5.06E-07	1.00E-03	-	-
			Carcinogenic Risk	**1.72E-05**		**Hazard Index**	3.60E-02

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk (ug/m^3)$^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Tetrachloroethene	3.28E+00	2.69E-01	5.90E-06	**1.59E-06**	3.14E-03	2.70E-01	1.16E-02
Trichloroethene	4.39E-01	3.61E-02	2.00E-06	7.21E-08	4.21E-04	--	-
			Carcinogenic Risk	**1.66E-06**		**Hazard Index**	1.16E-02
		Total Carcinogenic Risk - Groundwater Exposure		**8.41E-05**	**Total HI - Groundwater Exposure**		1.88E-01

Notes:

Values in **bold** indicate a cancer risk >1x10^{-6} or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter

Table I-13
Risks to Current/Future Visitors
Off-Base Surface Water
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION OF SURFACE WATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Surface Water (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	4.70E-01	4.41E-10	5.40E-01	2.38E-10	5.15E-09	1.00E-02	5.15E-07
			Carcinogenic Risk	2.38E-10		**Hazard Index**	5.15E-07

DERMAL CONTACT WITH SURFACE WATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Surface Water (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Tetrachloroethene	4.70E-01	1.08E-08	5.40E-01	5.83E-09	1.26E-07	1.00E-02	1.26E-05
			Carcinogenic Risk	5.83E-09		**Hazard Index**	1.26E-05
			Total Carcinogenic Risk - Surface Water	6.07E-09		**Total HI - Surface Water**	1.31E-05

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table I-14
Risks to Future Commercial Workers
North Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Carbon tetrachloride	140	9.78E-04	7.00E-02	**6.85E-05**	2.74E-03	4.00E-03	6.85E-01
Chloroform	93.8	6.56E-04	3.10E-02	**2.03E-05**	1.84E-03	1.00E-02	1.84E-01
1,2-Dichloroethane	6.02	4.21E-05	9.10E-02	**3.83E-06**	1.18E-04	2.00E-02	5.89E-03
Naphthalene	0.24	1.68E-06	--	**-**	4.70E-06	2.00E-02	2.35E-04
Trichloroethene	65.8	4.60E-04	5.90E-03	**2.71E-06**	1.29E-03	-	-
			Carcinogenic Risk	**9.54E-05**		**Hazard Index**	8.75E-01

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk $(ug/m^3)^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Carbon tetrachloride	1.34E+00	1.09E-01	6.00E-06	6.55E-07	3.05E-04	1.00E-01	3.05E-03
Chloroform	3.05E-01	2.48E-02	2.30E-05	5.71E-07	6.95E-05	9.80E-02	7.10E-04
1,2-Dichloroethane	1.24E-02	1.01E-03	--	-	2.82E-06	2.40E+00	1.18E-06
Naphthalene	2.46E-04	2.01E-05	3.40E-05	6.83E-10	5.63E-08	3.00E-03	1.88E-05
Trichloroethene	5.87E+01	4.78E+00	2.00E-06	**9.57E-06**	1.34E-02	--	-
			Carcinogenic Risk	**1.08E-05**		**Hazard Index**	3.78E-03
		Total Carcinogenic Risk - Groundwater Exposure		**1.06E-04**	**Total HI - Groundwater Exposure**		8.78E-01

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$µg/m^3$ = micrograms per cubic meter

Table I-15
Risks to Future Construction Workers
North Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INHALATION OF VAPORS IN TRENCH - GROUNDWATER							
		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	**RME Concentration in Trench Air (ug/m^3)**	**Exposure Concentration (ug/m^3)**	**Inhalation Unit Risk $(ug/m^3)^{-1}$**	**Risk Probability**	**Exposure Concentration (mg/m^3)**	**Reference Concentration (mg/m^3)**	**Hazard Quotient**
Carbon tetrachloride	8.92E+01	6.98E-02	6.00E-06	4.19E-07	9.78E-03	1.00E-01	9.78E-02
Chloroform	9.62E+00	7.53E-03	2.30E-05	1.73E-07	1.05E-03	9.80E-02	1.08E-02
1,2-Dichloroethane	1.65E-01	1.29E-04	--	-	1.81E-05	2.40E+00	7.52E-06
Naphthalene	1.84E-03	1.44E-06	3.40E-05	4.89E-11	2.01E-07	3.00E-03	6.71E-05
Trichloroethene	1.44E+01	1.13E-02	2.00E-06	2.25E-08	1.58E-03	--	-
			Carcinogenic Risk	6.15E-07		**Hazard Index**	1.09E-01
			Total Carcinogenic Risk - Groundwater Exposure	6.15E-07	**Total HI - Groundwater Exposure**		1.09E-01

Notes:
Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
$\mu g/m^3$ = micrograms per cubic meter

Table I-16
Risks to Future Adult Residents
North Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Carbon tetrachloride	140	1.32E-03	7.00E-02	**9.21E-05**	3.84E-03	4.00E-03	9.59E-01
Chloroform	93.8	8.81E-04	3.10E-02	**2.73E-05**	2.57E-03	1.00E-02	2.57E-01
1,2-Dichloroethane	6.02	5.65E-05	9.10E-02	**5.15E-06**	1.65E-04	2.00E-02	8.25E-03
Naphthalene	0.24	2.25E-06	--	**-**	6.58E-06	2.00E-02	3.29E-04
Trichloroethene	65.8	6.18E-04	5.90E-03	**3.65E-06**	1.80E-03	-	-
			Carcinogenic Risk	**1.28E-04**		**Hazard Index**	**1.22E+00**

DERMAL CONTACT - GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Dermally Absorbed Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Dermally Absorbed Dose (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Carbon tetrachloride	140	2.37E-04	7.00E-02	**1.66E-05**	6.90E-04	4.00E-03	1.72E-01
Chloroform	93.8	5.17E-06	3.10E-02	1.60E-07	1.51E-05	1.00E-02	1.51E-03
1,2-Dichloroethane	6.02	6.47E-05	9.10E-02	**5.89E-06**	1.89E-04	2.00E-02	9.43E-03
Naphthalene	0.24	1.51E-06	--	**-**	4.39E-06	2.00E-02	2.20E-04
Trichloroethene	65.8	1.07E-04	5.90E-03	6.33E-07	3.13E-04	-	-
			Carcinogenic Risk	**2.32E-05**		**Hazard Index**	1.84E-01

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk $(ug/m^3)^{-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Carbon tetrachloride	1.34E+00	4.40E-01	6.00E-06	**2.64E-06**	1.28E-03	1.00E-01	1.28E-02
Chloroform	3.05E-01	1.00E-01	2.30E-05	**2.30E-06**	2.92E-04	9.80E-02	2.98E-03
1,2-Dichloroethane	1.24E-02	4.07E-03	--	**-**	1.19E-05	2.40E+00	4.94E-06
Naphthalene	2.46E-04	8.10E-05	3.40E-05	2.76E-09	2.36E-07	3.00E-03	7.88E-05
Trichloroethene	5.87E+01	1.93E+01	2.00E-06	**3.86E-05**	5.63E-02	--	-
			Carcinogenic Risk	**4.35E-05**		**Hazard Index**	1.59E-02
		Total Carcinogenic Risk - Groundwater Exposure		**1.95E-04**	**Total HI - Groundwater Exposure**		**1.42E+00**

Notes:

Values in **bold** indicate a cancer risk $>1x10^{-6}$ or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
mg/kg/day = milligrams per kilogram per day
mg/m^3 = milligrams per cubic meter
RME = reasonable maximum exposure
µg/L = micrograms per liter
$µg/m^3$ = micrograms per cubic meter

Table I-17
Risks to Future Child Residents
North Plume Groundwater
Site 11 RI, Buckley Air Force Base, Colorado

INGESTION OF GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Lifetime Average Daily Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Chronic Daily Intake (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Carbon tetrachloride	140	7.67E-04	7.00E-02	**5.37E-05**	8.95E-03	4.00E-03	**2.24E+00**
Chloroform	93.8	5.14E-04	3.10E-02	**1.59E-05**	6.00E-03	1.00E-02	6.00E-01
1,2-Dichloroethane	6.02	3.30E-05	9.10E-02	**3.00E-06**	3.85E-04	2.00E-02	1.92E-02
Naphthalene	0.24	1.32E-06	--	**-**	1.53E-05	2.00E-02	7.67E-04
Trichloroethene	65.8	3.61E-04	5.90E-03	**2.13E-06**	4.21E-03	-	**-**
			Carcinogenic Risk	**7.48E-05**		**Hazard Index**	**2.86E+00**

DERMAL CONTACT WITH GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Groundwater (ug/L)	Dermally Absorbed Dose (mg/kg/day)	Oral Slope Factor (kg-day/mg)	Risk Probability	Dermally Absorbed Dose (mg/kg/day)	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Carbon tetrachloride	140	1.32E-04	7.00E-02	**9.27E-06**	1.55E-03	4.00E-03	3.86E-01
Chloroform	93.8	2.89E-06	3.10E-02	8.97E-08	3.38E-05	1.00E-02	3.38E-03
1,2-Dichloroethane	6.02	3.74E-05	9.10E-02	**3.41E-06**	4.37E-04	2.00E-02	2.18E-02
Naphthalene	0.24	8.44E-07	--	-	9.84E-06	2.00E-02	4.92E-04
Trichloroethene	65.8	6.01E-05	5.90E-03	3.55E-07	7.01E-04	-	-
			Carcinogenic Risk	**1.31E-05**		**Hazard Index**	4.12E-01

INHALATION - INDOOR VAPOR INTRUSION FROM GROUNDWATER		Cancer Risk Calculations			Non-Cancer Hazard Calculations		
COPC	RME Concentration in Indoor Air (ug/m^3)	Exposure Concentration (ug/m^3)	Inhalation Unit Risk (ug/m$^{3)-1}$	Risk Probability	Exposure Concentration (mg/m^3)	Reference Concentration (mg/m^3)	Hazard Quotient
Carbon tetrachloride	1.34E+00	1.10E-01	6.00E-06	6.60E-07	1.28E-03	1.00E-01	1.28E-02
Chloroform	3.05E-01	2.50E-02	2.30E-05	5.76E-07	2.92E-04	9.80E-02	2.98E-03
1,2-Dichloroethane	1.24E-02	1.02E-03	--	**-**	1.19E-05	2.40E+00	4.94E-06
Naphthalene	2.46E-04	2.03E-05	3.40E-05	6.89E-10	2.36E-07	3.00E-03	7.88E-05
Trichloroethene	5.87E+01	4.82E+00	2.00E-06	**9.65E-06**	5.63E-02	--	-
			Carcinogenic Risk	**1.09E-05**		**Hazard Index**	1.59E-02
			Total Carcinogenic Risk - Groundwater Exposure	**9.88E-05**		**Total HI - Groundwater Exposure**	**3.29E+00**

Notes:

Values in **bold** indicate a cancer risk >1x10^{-6} or a HI >1.0.
"-" - There is no toxicity data for this COPC, so no risk can be calculated.

COPC = Chemical of Potential Concern
HI = hazard index
kg-day/mg = kilogram-day per milligram
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